

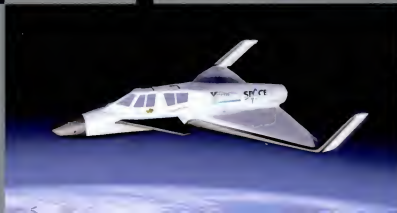
50,000 Fighters! The Digital Science of Lord of the Rings 2

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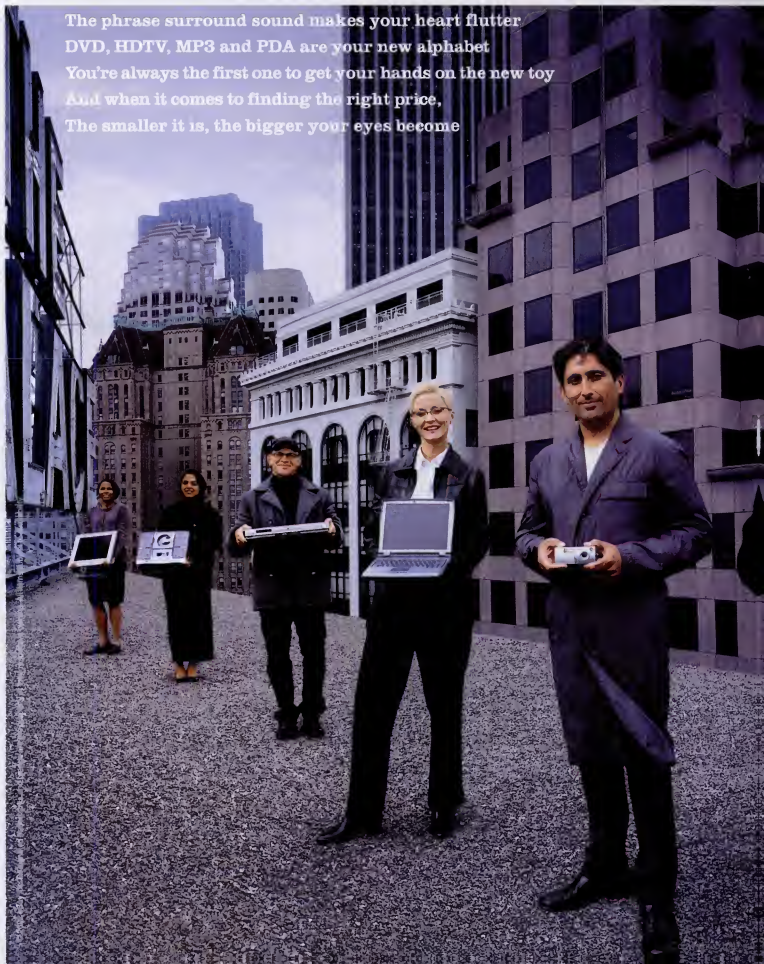
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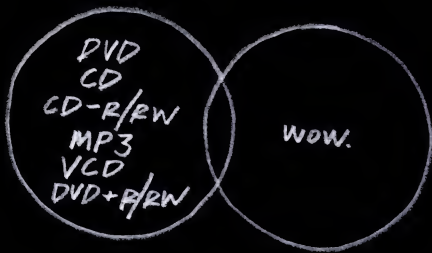
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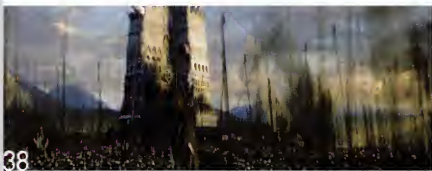
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THE BEST OF WHAT'S NEW
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Must Upgrade Now!

I SETTLED INTO THE BEAUTIFUL OLD HANDMADE WOODEN canoe and pushed off from the boathouse dock, ready to take a turn about a northern lake, feeling, as one does at such moments of calm command, like a descendant of a great explorer. Then I flipped the damned boat over and fell into the lake.

For someone who grew up summering at a lake and had canoed since the age of 8, this was like hopping onto a bicycle and riding straight into a wall. What a guy does in this sort of situation, of course, is pretend that absolutely nothing has happened. Then I noticed an object lying in 6 inches of water below the stern thwart of the canoe—my until-recently top-of-the-line 3.3-megapixel digital camera with three-times optical zoom. Oops. Yet as I studied this thousand-dollar piece of ballast, it took me about a millisecond to understand that here was the excuse I needed to move up to one of the cool new 5-megapixel jobs.

On the phone, the nice Midwestern insurance agent, who sounded like she had paddled around a few lakes in her time, explained that the "overturned conveyance" rider on my policy didn't cover overturning the conveyance. No matter. In that split second in the lake I had been struck by a feeling that anyone who loves technology understands: the irresistible urge to upgrade. This compulsion leads to a research phase (brochures, Web browsing or, if you're lucky like me, yakking with Technology Editor Suzanne Kantra Kirschner) and then to the final, fatal purchase response. The equation is simple: failure to upgrade skills with tippy old-tech canoe leads to costly but satisfying hardware upgrade reaction.

It occurs to me that variations on this urge lie behind pretty much everything we cover in POPULAR SCIENCE: the drive to upgrade software, hardware, knowledge, performance, even our bodies. Our 15th annual Best of What's New Issue—spearheaded by Kantra Kirschner, edited by Executive Editor Bill Phillips and shot by Photo Editor John Carnett—is the biggest, boldest ever. Hope you enjoy, and begin your upgrade plans immediately.



Scott Mowbray
 scott.mowbray@time4.com



THE NISSAN ALTIMA



Letters

Mini-Nukes: Essential or Mad?

Developing a small-yield nuclear bunker buster ["The Bunker Nightmare Goes Nuclear," Oct.] should be our highest priority. That means we need to return to underground nuclear testing—an activity we should never have stopped.

After more than 10 years without testing, we have lost most of our capabilities to resume. After the demise of the Soviet



Union we were lulled into believing the world was a safe place and that we had no major enemies to worry about—what a mistake! Our entire nuclear system is in disarray and now we have many potential adversaries. When will we learn that the nations on this Earth will never be totally at peace? Technology continually advances—we cannot let our systems decay and expect to survive. Our nuclear weapons development needs to be on the cutting edge.

Paul Mudra
Dept. of Energy (ret.)
Las Vegas, Nev.

When are the people on this little ball of dirt going to realize that this is the *only* home we have, and when we have managed to destroy it with nukes and chemical horrors—then what? Ole H. Nielsen
London, Ontario, Canada

In regard to nuclear bunker busters: What about the risks associated with a dud weapon? It would seem that the chances of the fragile and untested electronics not firing correctly are fairly high. Would this not deliver the

perfect gift of weapons-grade plutonium into the hands of a rogue nation? In many cases it may be the last ingredient that the underground nuclear facility—that was supposed to be destroyed—was waiting for.

Erik Putz
Smithtown, N.Y.

To call a bunker buster a "mini-nuke" is an oxymoron. It sounds cuter and less dangerous, but compared to conventional weapons, any nuclear explosion is not "mini." We know that radiation is

harmful from the countless tests done with nuclear devices.

Your article says "a 5-kiloton nuke would produce a limited amount of poisonous nuclear fallout capable of killing nearby civilians." But contamination in the atmosphere is not the only danger. Many of these bunkers are situated in mountainous terrain where headwaters of creeks and rivers are located. Groundwater flowing through the radiated blast zones will mobilize the contaminants and bring them to inhabited regions, poisoning well water used for human consumption and agricultural purposes.

Nathan Isherwood
Maple Ridge, British Columbia,
Canada

Sharing the Rush

Finally, an article on drag racing ["What a Rush," Oct.]. It's one of the most technologically advanced sports: not only in recording the aspects of a run but also in the knowledge it takes to rebuild an entire engine in 75 minutes and the precise tuning it takes to get a car to run just right. It also is extremely difficult to build an engine and chassis that can

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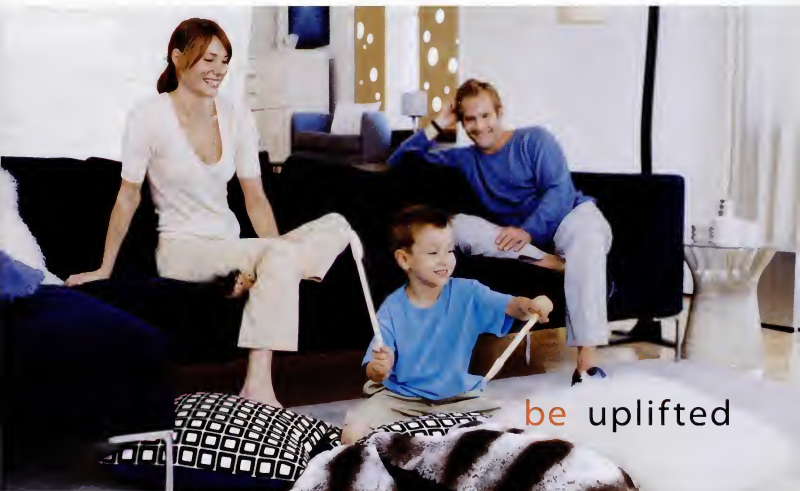
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Letters

Free
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withstand the strain nitromethane delivers. I'm glad Ted West got the chance to see what it feels like in the car—watching a dragster does not compare to actually driving one.

*Michael Pavesich
Chicago, Ill.*

F1: To Bore or Not to Bore

I could not agree more with Stephan Wilkinson about Formula One racing ["F1 Racing: Wow! What a Bore!" *Man & Machine*, Oct.]. Thank you for putting both of our thoughts into a well-written article. I believe that the many problems with Formula One are all caused by one underlying notion—F1 is about the cars and drivers, not the fans.

*Abraham Feng
Berkeley, Calif.*

"Demitasse-size pistons"? Sounds like this guy has spent too much time sipping gourmet coffee and not enough time outdoors.

*Kenny Mankin
San Mateo, Calif.*

Forensic Reality

As much as I enjoy *CSI* on television, reality does enter the world of forensic science ["Crime Seen," Oct.]. Several forensics "experts" have been caught giving bogus credentials in court, and many prosecutors shop for experts who achieve convictions instead of those who consider truth foremost. Remember that O.J. Simpson's trial showed that some of the forensic evidence might have been tampered with.

*Marvin Lewis
Philadelphia, Pa.*

Tricked-Out Cars: Illegal? Irresponsible? Both?

It was irresponsible to publish "10 Customization Moves" [What's New, Oct.]. A more appropriate title would be "Achieving Total Disregard for the Rest of Society."

The use of "public address grade" speakers in an automobile is nothing short of assault. The bass these systems put out can be heard and felt inside a closed home or car from a mile away. The risk of these "boom cars"

extends far beyond disturbing the peace—they affect the concentration of other drivers and increase the potential of not hearing and responding to emergency vehicles for both the offending car and those in close proximity. I am disappointed that *POPULAR SCIENCE* would promote such reckless and careless behavior.

*Curt Dansby
Charlotte, N.C.*

I urge anyone thinking of tricking out their vehicle to carefully check their state's motor vehicle laws. Several of your 10 moves are outright illegal in this state, and others may be, depending on how the item is installed. Most aftermarket items contain a warning that the item may not be street legal. The bottom line is, know before you spend the dough.

*Tim Hardy
Deputy Sheriff
Kathleen, Ga.*

Brain Chemistry No Excuse

I was quite insulted by the article "You Dirty Vole" [Oct.]. How chemicals in the brain affect mating relationships between voles is one thing; to even *hint* at a translation to humans is quite another. When a spouse violates the marriage vows, it is due to a conscious decision, not brain chemistry.

*J. Andrew Howe
Vallejo, Calif.*

Mind-Ratling Hypersonic Sound

I would like to thank Woody Norris ahead of time for my next new toy ["Audio's Next Big Thing?" What's New, Oct.]. I can't wait until the hypersonic megaphone comes out—I can just imagine the pointed messages Chicago Cubs players will be receiving in the batter's box when they travel to Comiskey Park for interleague play.

Seriously, the havoc one could wreak with this technology boggles my mind. Any task that requires concentration could be interfered with, and it would be untraceable by law enforcement.

*Matt Doran
Hammond, Ind.*



Touting Skycar

In the future, we will have an air taxi system, but it won't be based on aircraft that need a runway ["Taxi! Taxi!" Oct.]. Your article ignores advances in VTOL technology that you yourself have covered in the past—namely Paul Moller's Skycar ["Dream Machine," March '00], a four-passenger vehicle with a 1,000-mile range, capable of vertical takeoff and landing and cruising at 350 mph. Yes, vehicles like the Eclipse will play a role in eliminating current airport congestion, but it will be the Skycar that will form the backbone of any air taxi system.

*Faulkner White
Irvine, Calif.*

Your article on air taxis makes no mention of integrating our existing highway transportation, light rail, railroad and air systems into a smooth, understandable national public transportation system. I would have thought that NASA, being federally funded, would have at least included mention of ground transportation alternatives.

*Roger Jacobson
Eden Prairie, Minn.*

How to Jam Jingles

I too do not appreciate the jingle of cellular phones while dining ["The No-Jingle Zone," NewsFiles, Oct.]. Blocking all RF signals, however, is not the way to eliminate this problem. Many of the transmissions necessary to police and fire departments are sent on frequencies in the same range as cellular transmissions—and police and fire personnel eat at restaurants.

A better solution would be the one used by some government agencies: transmitting a signal that would disable or turn off only cellular phones.

*Andrew Shecktor
Volunteer Fire Police Assn.
Montgomery County, Pa.*

Are Cellphones Safe? The Industry's View

Regarding the article "FDA, It's Time to Study Cellphone Radiation," [What's New, Sept.]: On one hand, Suzanne Kantra Kirschner's assessment of the potential of health issues involving cellular phones is correct—a confusing volley of scientific research has appeared in the popular media. However, to suggest that the best resolution is for the FDA to conduct its own research is to be unaware of the studies already conducted, and of the worldwide process that brings together the FDA and other international public health agencies. All of these agencies collectively review the scientific research and reach a consensus opinion.

Public health agencies and policymakers are not moved by sensational media reports on the "latest study." They understand that public health policy is developed by considering the widest range of research, not highlighting single studies in isolation. Unfortunately, the public receives news reports that don't provide appropriate context but rather sensationalize—and sometimes distort—single studies.

The FDA has already issued a statement that echoes what other public health agencies around the world have concluded: "The available scientific evidence does not show that any health problems are associated with using wireless phones" (www.fda.gov/cell-phones). Perhaps the answer to Kantra Kirschner's suggestion that "It's time to put this issue to rest" would best be served by bringing to the public's attention the extensive reviews that have been conducted and the conclusions they have reached thus far.

*Jo-Anne R. Basile
Cellular Telecommunications and
Internet Association (CTIA)
Washington, D.C.*

CORRECTIONS

F1 driver Michael Schumacher's name was misspelled due to an editing error in the story "F1 Racing: Wow! What a Bore!" [Man & Machine, Oct.].

The asteroid that buzzed Earth in June came within 75,000 miles, not 750,000. ["Chicken Little or Planetary Savior?" Test Pages, Oct.].

AMD
me.

Learning to fly a Helo is Like...



Circular Error Probable

A veteran airplane pilot falls in love with the weirdness of helicopter flying.

By Stephan Wilkinson

couple of years ago, I flew a big ex-Vietnam Marine helicopter, a 1,525-horsepower, radial-engine UH-34D that in its day was the Escalade EXT of the air. In truth, I simply manipulated the controls from the co-pilot's seat for 15 minutes once the owner of the nicely restored Dog had taken off and established us in level flight over Houston.

I promptly disestablished level flight. After a few minutes of watching me corkscrew through the Texas sky, the pilot keyed his mike and said, "If I have a heart attack, you have 40 seconds to live."

He was right. I'd been flying a wide variety of airplanes for 30 years, but the only way I'd have gotten the porky Sikorsky onto the ground was as a lawn dart. Yet *trying* to fly it was the most

(CONTINUED) ►

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fun I'd had in the air since I soloed a Stearman biplane. I needed more.

My friend Mario, an FAA examiner and helicopter instructor, operates three piston and two turbine helos off his broad lawn in . . . well, I won't tell you, because Mario keeps a low profile and takes new students only if they've been signed off on by the Pope. Most are aerial-unit cops, state troopers, MedEvac pilots and corporate guys. And now me, terrified to be in the hands of this hardass who's essentially seen it all.

"Flight instruction is supposed to be fun," Mario growls as we preflight a two-seat Robinson R22 for my first lesson. "But learning to fly a helicopter is sheer torture. I can't tell you how

rudder locks still in place.) Airplane controls also require gross inputs. Most lightplanes, from two-seat Cessnas to big pressurized twins, are about as touchy as a '49 Hudson.

A helo's controls are different. Until the movements become second nature, you have to *think* about what you're doing. One cliché image is that flying a helicopter is like patting your head while rubbing your tummy. Another compares it to balancing atop a greased beachball. And the controls require only pressure, not real movement. A helicopter pilot friend who is also a serious radio-control modeler swears that a Robinson trainer requires tinier control inputs than do the inch-long joysticks on his R/C controller.

another stick called the cyclic. Say SIGH-click. (And while we're at it, don't ever say chopper or copter. The only people who do are TV blow-dry weather types and other amateurs. If four syllables are a burden, call it a HEE-low.) With the cyclic, you control the helicopter's bank, the up-or-down angle of its fuselage, and generally your track over the ground.

Ignore a helo's anti-torque pedals at your peril. Ignore them, in fact, and you'll find yourself a passenger on a giant flying pinwheel. They control the small propeller—or in some cases a ducted fan or blower—at the tail of the bird. If it weren't there, a helicopter's fuselage would rotate in one direction around the main rotor shaft about as fast as the rotor blades were turning in the opposite direction. Particularly while trying to hover, the pedals are crucial.

Bomber pilots call it CEP—Circular Error Probable, the circle around a target within which 50 percent of their bombs are statistically expected to land. That idea is also useful in determining the amount of real estate a novice helo driver will cover while attempting to hover over a spot. My CEP during that first lesson was half an acre of the onion fields and sod farms over which we practiced, to the bemusement of at least one tractor driver who obviously had no idea that my CEP happened to include him.

The tractor guy was gone during my next session with Mario over the same fields, but he'd have been impressed. This time, I actually hovered. Not for long, mind you, but for those few pure, perfect, I'm-a-hummingbird moments when the little Robinson rested calmly in the air 3 feet above the vegetables, I was in control of the most marvelous flying machine the world has ever seen. Thank you, Igor Sikorsky.

But one question, Igor: How did you learn to hover on your first helicopter flight without Mario to say calmly, "Left pedal, more left pedal, watch your attitude, add some power, left cyclic, keep the nose up, left some more...I've got it." How the hell did you manage to do that, Igor? ■

My teacher warns me: "Pilots will say, 'What's wrong? How can I tame this thing?' All I tell them is, 'Give me more money.'"

frustrating it is. If there were a way for me to plug you in so that I could instantly transfer what I know, I'd do it. But flying a helicopter requires repetition. Doing it over and over again until you finally memorize the right control inputs." My first few hours of instruction will be miserable, frustrating and terminally discouraging, Mario promises me.

"A professional pilot with thousands of hours of business-jet time will come to me and beg, 'What am I doing wrong, how can I figure out how to tame this little thing?'" Mario says. "All I can tell them is, 'Give me more money. You haven't done it enough yet.'"

The R22 costs \$175 an hour with Mario instructing. This is getting close to twice what it costs for flying lessons in an equivalent fixed-wing Cessna. Mario's Bell 206 JetRanger goes for \$600 an hour.

The controls of an airplane are intuitive. Push to nose down, pull to nose up, turn left, turn right. You can put your feet flat on the floor, ignore an airplane's rudder pedals and still get where you're going. (I once numbly flew a 200-mile trip in a Beech Bonanza that I'd never flown before, with the

Mario is a muscular little fireplug of a guy, but his movements become as sleek as a tango dancer's as he plays air guitar with imaginary helicopter controls to show me how the aircraft responds to the merest thought transmitted through the proper pressures. "Women make better students," he says, "because they naturally have more finesse. If you need to wear your wife's underwear to get in touch with your feminine side, do it."

There's a stick called a collective in your left hand. It goes up and down like a sports car's parking brake and has a motorcycle-grip twist throttle on the end. In the era of that old UH-34D I'd mistreated, you turned the grip left to add power, right to remove it. Today, you do that only to warm up the engine and run a magneto check. Even on my tiny R22 trainer, the engine rpms are managed automatically and power is actually added by pulling up on the collective, which coarsens the pitch of the main rotor blades and forces the engine to put out more power.

In your right hand, you're holding



Stephan Wilkinson is hovering, waiting for e-mail at manandmachine@time4.com

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Bye-bye Miss American Pie
Drove my Chevy to the levee
But the levee was dry

-Don McLean



WE'LL BE THERE

EDITED BY CHARLES HIESBERG

epidemiology

Preventing a Pox Americana

The government may let you have a smallpox injection, if you choose. Should you get one?

POX STOPPERS
Researcher at Atlanta's Centers for Disease Control and Prevention (right) prepares a lab set aside for smallpox research. In Israel (far right), health workers must be vaccinated.



is no cure, and the disease brings a 30 percent chance of death to anyone it infects. Yet many doctors fear vaccination more than an outbreak, because the potential for vaccine side effects—from fevers to encephalitis and death—may outweigh the odds of a smallpox attack.

A ferocious debate has erupted over who (if anyone) should receive the vaccine. All Americans born after 1971 (when vaccinations ceased) are vulnerable, and it's likely those inoculated prior to '71 are no longer immune. According to a recent poll, half of all Americans would choose vaccination if given the option. Federal officials favor offering vaccines to the public once 10 million health care workers are inoculated, and once the vaccine is licensed for general use, which isn't expected until 2004. That's when you may face a decision.

"Smallpox hasn't gotten less deadly just because we haven't seen it in 30 years," says Dr. Matthew Davis, a physician and researcher at the University of Michigan. "If there's a potential for a smallpox attack, which there seems

(CONTINUED) ►

gETTING A POTENTIALLY DEADLY VACCINE FOR A DISEASE that has been totally eradicated would have sounded crazy to most Americans until recently. Forty years ago, routine smallpox vaccines killed 1 in every million Americans vaccinated: an acceptable risk, because smallpox killed millions worldwide. But after the disease was eradicated in the 1970s, health officials discontinued the vaccine, which is now considered too dangerous for general use. Today, with weapons-grade smallpox possibly in the hands of our enemies, citizens face important questions: Has our definition of acceptable risk become too narrow? When it's available, should we accept smallpox vaccination again?

Treatments for smallpox are in the works (see page 74), but there

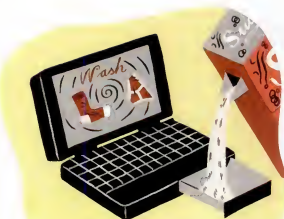
to be, shouldn't we protect ourselves?"

John Modlin, chair of the Centers for Disease Control Advisory Committee on Immunization Practices, disagrees: "If we were to immunize the entire population, even with screening, there would be a substantial number of adverse events, including death," Modlin says.

The smallpox vaccine is made from a live virus called vaccinia—a relative of smallpox that causes a mild infection. Human immune systems generally fight it off easily, then develop immunity to vaccinia and the related smallpox. But some people's immune systems can't combat the virus, and vaccinia becomes a potentially deadly infection that spreads.

Death rates could be higher now than 30 years ago, Modlin says, because more patients have conditions, ranging from AIDS to asthma, that make them vulnerable. Michigan's Davis disagrees, saying careful prescreening of the population would identify high-risk patients, who would not receive the vaccine. Having compared mathematical models of smallpox attacks in populations that did and did not receive inoculation, he likes the vaccine's odds.

Although childhood immunizations were a cornerstone of smallpox eradication, the American Academy of Pediatrics opposes vaccinating children now, citing a lack of suitable testing. But Davis says his mind is made up. "My parents didn't think twice about vaccinating me as a child," he says. "Would I get the vaccine now if I could? Absolutely." —REBECCA SKLOOT



science of art

WALKING ON THE WIND

Ten years ago, Dutch scientist-turned-artist Thea Jansen had a vision: art that evolved. The evolution of his bizarre machines that walk when powered by gusts of wind took place on a computer. Trained as a physicist (he was a doctoral student but did not finish), Jansen designed a program that simulated pairs of legs of different lengths. He then created virtual creatures and raced them against each other to find the ones that moved most efficiently. These he built, and he hopes one day to find a way to let them evolve on their own. In the meantime, he is working on ways to keep them moving even after the wind dies down. Their legs are comprised of pistons inside a tube, connected to a crankshaft. Once a gust of wind gets the sculpture going (most have polystyrene windmill blades or sails to give them a boost) and the pistons start moving, the legs could function as pumps and store compressed air. The critter could then burn that stored energy to keep pattering along regardless of the weather. "It's like giving it muscles," says Jansen with delight. —GUNJAN SINHA



To see the beasts in motion, go to www.popsi.com/beachbeasts.



web update

WIRED STUDENTS CLEAN UP ACT

NOT LONG AGO, PUNDITS proclaimed that the Internet was about to revolutionize our lives. Fast forward to today and . . . we have eSuds.net. Not exactly a sea change, but it may prevent college students from squandering precious homework and party time in laundry rooms. Before trudging off with their hampers, eSuds users check a Web site to see if empty laundry machines are available (if the equipment is in use, the remaining cycle time is displayed). Once a student starts a machine, he or she can add fabric softener via an online command. And when the wash is done, the system sends an e-mail, page or cellphone text message. The washers and dryers are connected to a central hub that collects sales, service, usage and availability information, and wirelessly transmits the data to an Internet server at an operating center. USA Technologies, which developed the system, notes happily that in a pilot launch at Boston College and MIT, students did their laundry more often. A distributor is now hawking eSuds to schools nationwide. —JENNIFER USCHER

PAUL BLOW



BEACH BEASTS Dutch artist Theo Jansen's strange creature-like sculptures have strange creature-like names: *Animaris Sabulosa* (left); *Animaris Rigide Ancora* (above left) and *Animaris Currens Ventosa* (above right).

medicine

The Botox Club Cure

bOTOX, THE ANTI-WRINKLE TREATMENT, IS ALL THE RAGE AMONG ADULTS who don't mind the needle if it will keep them looking young. But research shows that the medication—a toxin that works by causing temporary paralysis of muscles—can also help the genuinely young. As many as 1 in 500 babies are born with clubfoot, a condition in which the heel and toes twist inward. The deformity is corrected by moving the foot into a healthy position and stabilizing it with a cast for several months.

Before this procedure, most babies need to undergo tendon-lengthening surgery so their feet can be comfortably turned. Because Botox lengthens tendons by relaxing them, surgery wasn't required in trials conducted by Dr. Christina Alvarez of Children's Hospital in Vancouver. She injected Botox into the calves of some 40 babies, repositioned their club feet and stabilized them with casts. All grew into healthy toddlers. —HARALD FRANZEN



TWISTED TOOTSIES No one is certain what causes this rather common deformity, but a new treatment is emerging from, of all things, a beauty medication.

space shuttle

Look Back in Awe

Just for the wow of it, an onboard shuttle cam lifts off.

AFTER TWO DECADES OF WATCHING IDENTICAL SHUTTLE liftoffs from Kennedy Space Center (with one horrible exception) fans finally get a new angle from which to appreciate the spectacle, thanks to an onboard camera mounted above the orbiter on the external fuel tank.

The camera, named RocketCam and built by CrossLink Inc. (which has since sold the product to Ecliptic Enterprises Corp.), made its debut with the launch of space shuttle Atlantis on mission STS-112 this October 7. Though there were several jarring interruptions by NASA producers—who cut away to exterior views at all the best moments—the camera produced breathtaking wide-angle images of the rapidly receding space center and Florida coastline. “We wanted to share what is really a thrilling event,” NASA spokesman Rob Navias says, “and I must say it was pretty stunning.”

RocketCam is an off-the-shelf industrial Sony model built into a highly specialized protective casing at a cost of roughly \$750,000 (regular use should bring the price down to about \$100,000). It is positioned near the top of the external fuel tank and aimed downward.

The perspective promised first-ever onboard views of the solid rocket booster separation 2 minutes into the flight, as well as the orbiter detaching from the external tank 5 minutes later. The camera performed flawlessly from liftoff, but its positioning on the external tank, in the path of the propellants from small rockets that assist in the SRB separation, led to residue smudging and robbed viewers of as many as 15 more minutes of the ride to space. “That was the only thing that disappointed us,” says Rex Ridenoure, CEO of Ecliptic Enterprises. “We knew it was going to happen, but NASA didn’t think it would.” He adds that he will encourage NASA to move the camera on future launches. It could be two years before we see this again, though. At press time, the camera wasn’t even scheduled into future launch manifests. “We wanted to wait and see how the public responded to it,” Navias says.—ERIC ADAMS

\$750,000 VIEW

The camera, mounted in pricey unit on cable tray near top of external tank, is encased in foam-covered aerodynamic housing.



IGNITION Engines fire, 4.5-million-pound shuttle lifts off.



10 SECONDS Already traveling at 120 mph, the shuttle clears the tower.



48 SECONDS At 750 mph, 2 miles downrange, shuttle breaks sound barrier.



1:26 SECONDS Just before SRB separation, 26 miles downrange, 2,800 mph.

FUN WHILE IT LASTED

RocketCam gave viewers 2 minutes of stunning footage before propellant smudged the view. No word when the camera will next be deployed.



For a closer look at the RocketCam video footage, go to www.popsi.com/shuttle



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The Plague of Evolution

IN 1348, WROTE ITALIAN POET GIOVANNI Boccaccio, the bubonic plague struck Europe, for which "neither the advice of physicians nor the power of medicine appeared to have any value." It "began with swellings in the groin and armpit, in both men and women, some of which were as big as apples and some of which were shaped like eggs . . . certain indications of coming death." Worst of all, "whenever the disease mixed with healthy people, like a fire through dry grass or oil, it would rush upon the healthy." A third of Europe's population was struck down by the Black Death. The unassuming culprit: a safety-pin-shaped bacterium named *Yersinia pestis*.

Today, scientists around the world are keenly interested in better understanding the bug. Not only because it still breaks out periodically, but also because of the unpredictable manner in which it evolves. With this in mind, Frederick Blattner and his colleagues at the University of Wisconsin's Genome Center decided to sequence the organism's DNA. By learning more about how it evolved in the past, they believe, perhaps scientists can better judge how the deadly bacterium might behave in the future.

Y. pestis has three major strains. Blattner's group focused on *Medievalis*, which is believed to be much the same as the variety that caused the Black Death.

Medievalis is similar to its two sister strains, with which it shares 95 percent of its genes. But Blattner was astonished to discover how many of *Y. pestis*'s genes come from other sources. Scientists can recognize these emigrant genes by examining how they are arranged and comparing them with genes from other bacteria. Genes that look odd—that is, rearranged or inverted—could have become so in several ways. In some cases, genes called transposable elements excise themselves from one position in a bacterium's DNA and insert themselves somewhere else. These "jumping genes" can also hop all the way into another bacterium. In other cases, bacteriophages—viruses that infect bacteria—pick up genes from one species and deposit them into another.

All this swapping and moving about forces the organism to evolve. When bacteria reproduce, each new bacterium is virtually identical to its parent (though it's not always an exact

The Paper Genome Sequence of *Yersinia pestis* KIM

The Journal *Journal of Bacteriology*, August 2002

The Author Wen Deng, Valerie Burland, Frederick Blattner et al.

The Gist Nothing holds down world population quite like jumping genes.



Before Translation

There are three regions where multiple inversions appear to have taken place. For each region we calculate the most parsimonious series of inversions that could account for the organizational differences between the two genomes. In most steps, it was possible to identify a sequence homology . . . that could have given rise to the proposed inversion.

copy, because cells can make mistakes when they replicate their DNA). Genes mutate on their own, but without genes from other sources, bacterial evolution would slow to a crawl.

In fact, the *Y. pestis* genome reveals that, as recently as 1,500 years ago, the organism could have evolved from a less harmful bacterium that infects people's innards. Over time, *Y. pestis* acquired genes from other bacteria and viruses that allowed it to live in an animal's blood rather than its intestine. At that point, it was able to jump from animals into people via the bite of an infected flea.

Today, about a dozen Americans are infected with plague each year, mostly in the rural West and Southwest. Worldwide, plague infects some 3,000 people annually. Could there be another pandemic as devastating as the Black Death?

Well, first the good news. Blattner says that *Y. pestis* evolves relatively slowly. Unlike viruses that mutate constantly, bacteria are, in general, much more stable. Now the bad news: Bacteria do indeed pick up new genes, as we have seen. A strain of plague found in Madagascar in the late 1990s, for example, was resistant to five antibiotics. The bacillus apparently picked up the genes that gave it hardness from another bacterial species. Yes, another huge, catastrophic outbreak is possible. But no one can predict when or where.—GUNJAN SINHA

"I wonder if he knows his plates are expired?"



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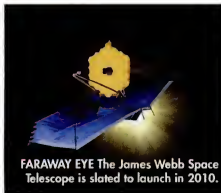


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FAREWAY EYE The James Webb Space Telescope is slated to launch in 2010.

astronomy

THE TELESCOPE-IN-A-BOTTLE PROBLEM

NASA IS SEARCHING FOR THE FIRST sunrise—that long-ago time when the first generation of stars ignited, flaring into life out of the uniform drabness that followed the Big Bang. The James Webb Space Telescope (named for the man who headed NASA in the 1960s) boasts a collapsible 20-foot mirror that will gather infrared light, unlike its predecessor the Hubble, which collected visible light. This will make the Webb far more able to catch rays from the universe's earliest stars.

But getting such a large mirror into space is neither easy nor cheap. To keep casts down, the mirror (twice the size of Hubble's) must be built of a lightweight, as-yet-undetermined material, and be able to fit into a small rocket. This poses what NASA project scientist John Mather calls the "telescope in a bottle" problem. Engineers plan to create a segmented mirror that unfolds in orbit. But its 36 segments will be flimsy, which means the materials can't be relied on to keep the mirror in perfect optical shape. The solution? Mechanical devices that minutely adjust each plate.

Another problem: Infrared telescopes need to be kept cold. Otherwise the ambient heat of the telescope and its surroundings interferes with measurements. To get the instrument away from our temperate planet, NASA plans to drag the Webb three months into space and dump it some 940,000 miles from Earth—four times farther than the moon. Perched in a mostly stable gravitational sweet spot in a direct line from the sun through the Earth, the telescope's outward gaze into deep space will never be obstructed by our planet or its atmosphere. A shield the size of a tennis court will protect the instrument from the sun and Earth, keeping it a crisp and cool minus 370°F.—KATIE GREENE

politics

Is Science Right?

Outgoing Arme y says liberals don't have sci-IQ.

dICK ARMEY, RETIRING MAJORITY LEADER OF THE HOUSE OF Representatives, created such a stir recently with comments about liberal and conservative Jews (the latter have all the brains, Arme y said), that another aspect of his comments attracted less notice: Science, according to Arme y, is the stomping ground of conservatives. "Conservatives," said the Texas Republican, "have a deeper intellect and tend to have occupations of the brain in fields like engineering, science and economics. Liberals, on the other hand, tend to flock to occupations of the heart."



**CONSERVATIVES
HAVE A DEEPER
INTELLECT &
TEND TO HAVE
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OF THE BRAIN IN
FIELDS LIKE
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LIBERALS, ON
THE OTHER
HAND, TEND TO
FLOCK TO
OCCUPATIONS
OF THE HEART.**

—DICK ARMEY

Arme y spokesman Richard Diamond concedes he has no evidence to back up Arme y's claim, although he insists that his boss stands by it. "It's his perspective about how people think," says Diamond.

Nor does a search for scientific evidence turn up much research into the broad political leanings of scientists. Neither the major scientific associations nor the polling firms were aware of studies.

Anecdotally, however, it's not hard to find blue chip scientists who take issue with Arme y—including some of the 53 Nobel laureates on the board of the Federation of American Scientists, a social policy organization often described as a "liberal think tank."

"Arme y is just completely wrong," says Nobel physicist Steven Weinberg of the University of Texas at Austin. "I have lots of political conversations with other physicists and my impression is that, on average, physicists are extremely liberal in their politics. I certainly am."

Nobel chemist Roald Hoffman of Cornell objects to Arme y's "assumption that occupations of the brain are somehow better than those of the heart. That's crazy. The United States is not a computer ... For [solving human problems], we need both the brain and the heart."

POPS UPDATE



AS WE REPORTED IN JULY, the Air Force has been panning a bomber version of the new F-22 Raptor fighter jet: a delta-wing variant called the FB-22. But budget cutbacks have grounded that plan. Top brass announced that the plane's name will be the F/A-22 Raptor—F/A, as in Fighter/Attack—but no new capabilities are being added. A decision by Defense Secretary Donald Rumsfeld to dramatically cut total plane orders, possibly to 200 from 400, is expected by year's end. Meanwhile, with his Raptor flock dwindling, Air Force Chief of Staff Gen. John P. Jumper is trying desperately to emphasize that "the Raptor will feed on prey both from the sky and from the [ground]." —ERIC ADAMS



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energy

Tower of the Sun

It's huge, it's green—and it may even happen.

aN AUSTRALIAN COMPANY WANTS TO PIONEER A NEW WAY OF getting energy from the sun. All it needs to do is build the tallest man-made structure in history—a 3,000-foot concrete chimney—in the outback.

Solar panels typically convert solar energy directly into electricity. But the facility planned by Melbourne-based EnviroMission would use heated air to power turbines that supply the electricity. The hot air would come from 7.5 square miles of glass or plastic around the chimney's base—a giant greenhouse. As the air warmed, it would rise toward the chimney. The result: a continuous flow that, on its way up, would spin the turbines' propellers.

The company estimates that the suction would create a 35-mph updraft that could power 32 turbines, generating up to 200 megawatts of electricity, or enough to supply 200,000 homes. The plant would keep working at night by a system of tubes filled with warm water. These tubes, heated by sunlight during the day, would continue to heat the air under the glass after dark and keep the power plant working.

The concept was tried over seven years in a much smaller prototype in Spain. But to be truly efficient, its designers say, scale is of the essence. A 3,000-foot tower wouldn't come cheap: The giant structure will cost an estimated \$670 million. The company argues that an expected life span of 100 years, combined with low maintenance costs and the absence of pollution, will make the endeavor worthwhile. The Australian government is expected to OK the construction, but so far has offered no money.—BOB SKLIERY

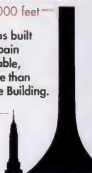
BIG DREAMS
The solar plant imagined by Australia's EnviroMission would collect warm air from miles of glass or plastic at the base of a giant chimney. On its way up the chute, the air would generate power by turning the blades of turbines.



A PROTOTYPE of the system was built in the 1980s in Manzanares, Spain (left). But to be economically viable, the chimney will have to be more than twice the size of the Empire State Building.

1,472 feet

3,000 feet





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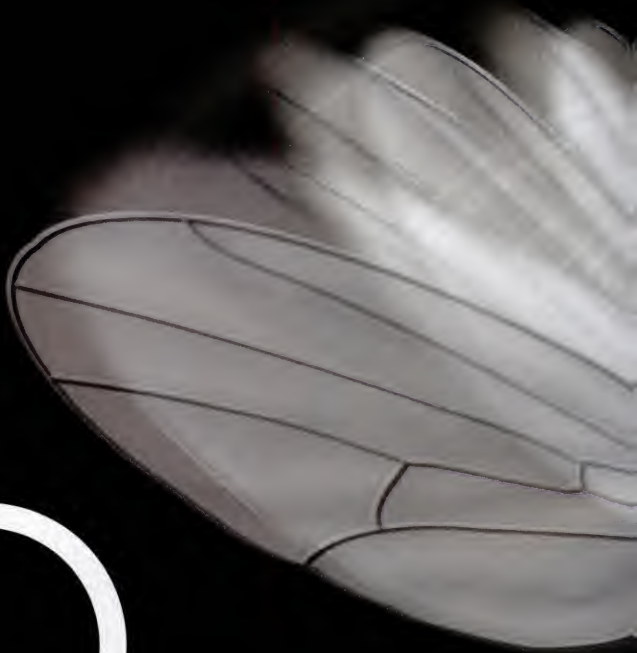
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FLUTTER BUG

Drosophila melanogaster

Beating 200 times a second,
the fruit fly's wings create some of the most complex aerodynamics found in nature;
here we simulate the blur from a 1/1000-second snapshot.



fly



drama!

To an insect, air is as thick as oil.

Michael Dickinson pursues the sticky question of
how these creatures maneuver so flawlessly.

The answers could spawn tiny new flying machines.

BY CARL ZIMMER

ILLUSTRATIONS BY STEPHEN ROUNTREE



IN THE BASEMENT OF THE VALLEY LIFE SCIENCES Building at the University of California, Berkeley, biologist Michael Dickinson walks down a cinderblock hallway to an anonymous steel door. Beyond it lies a small, windowless room crammed with high-speed video cameras and lasers and computer cables draped as thick as cobwebs. In the center of the room is a glass tank big enough to hold a vending machine. This is Robofly.

The tank looks empty, except for a piece of plastic shaped like an insect wing, which dangles from a mechanical arm. But when Dickinson turns on a filter, the tank sprays a creamy mist of bubbles. The tank, it turns out, is filled with 2 tons of mineral oil. Dickinson taps on a keyboard, and slowly the wing begins to move through the oil. It swings for-

ward and back, transforming the bubbles from a disorganized cloud into slow-motion swirls and falling curtains of diamonds.

Dickinson stands before Robofly, carefully watching vortex after vortex. A real fruit fly—an escapee from some other experiment, no doubt—drifts by, its wings beating 200 times a second and stirring up tiny, invisible vortices of their own. But Dickinson ignores it. Robofly has been his obsession for more than a decade, ever since he built the first prototype in Germany. Back then, he used sugar syrup in the tank. “There was sugar everywhere in the lab,” Dickinson recalls, “and the maids went on strike. They refused to clean our lab until my advisor did something about the sticky American.”

Stickiness is a good way to sum up Dickinson’s approach to science. Once he attaches himself to a problem he doesn’t let go until he’s solved it. For almost his entire career, he has been stuck on one seemingly simple question: How do flies fly?

Though engineers figured out decades ago how to build airplanes that cross oceans, the aerodynamics of insects continue to baffle them. The way an airplane generates lift can be accounted for by a straightforward concept: The air streaming over the top of the wings exerts less pressure than the air below, and that imbalance keeps the wings aloft. But insects, though equipped with barely a brain to speak of, make complex maneuvers far beyond an airplane’s capabilities. They turn quicker than any fighter jet and land upside-down on ceilings. “These animals can move perfectly sideways, they can move backward and forward, they can rotate in place,” says Dickinson. “Every time we do an experiment, we wonder how the hell do these little sesame-seed-size nervous systems do this?”

That question led him to build not just Robofly—which is 100 times larger and 1,000

times slower than a fruit fly—but a growing family of strange and wonderful machines with names like Bride of Robofly, Fly-o-rama, and the Rock-and-Roll Fly Arena, all designed to help reveal the secrets of insect flight. The answers that Dickinson, whose e-mail handle is “flyman,” gleams from those devices might someday enable engineers to build automated craft the size of rice grains that explore other planets, fly into burning buildings to search for victims, or spy on military opponents—literally, a fly on the wall. “He’s got a great engineer underneath that biologist exterior,” says Ronald Fearing, a Berkeley electrical engineer who has collaborated with Dickinson on building robotic flying devices.

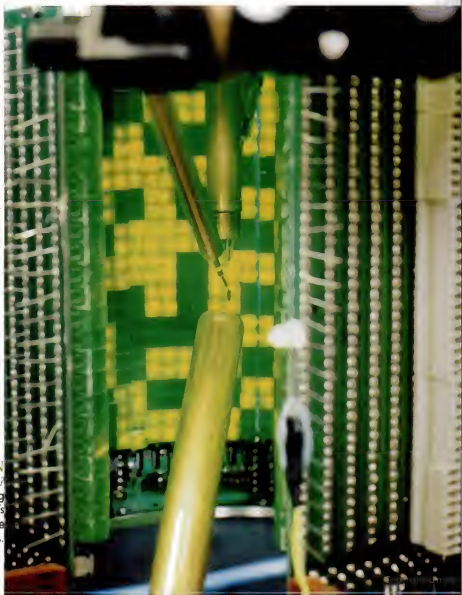
Last year, Dickinson’s research earned him a MacArthur “genius” fellowship, a grant of \$500,000 over five years, with no strings attached. MacArthur fellows are selected for their exceptional creativity, and for track records that promise important future advances. Dickinson was one of the last fellows to learn about his award. He had been backpacking with his fiancée in Hawaii, 18 miles into a Kauai forest. When he returned to civilization, he checked his voicemail and found frantic messages to call his lab, but his cellphone conked out in the rain before he could return any calls. He finally found a pay phone at a state forest where he had gone to watch fruit flies swarming in guava trees.

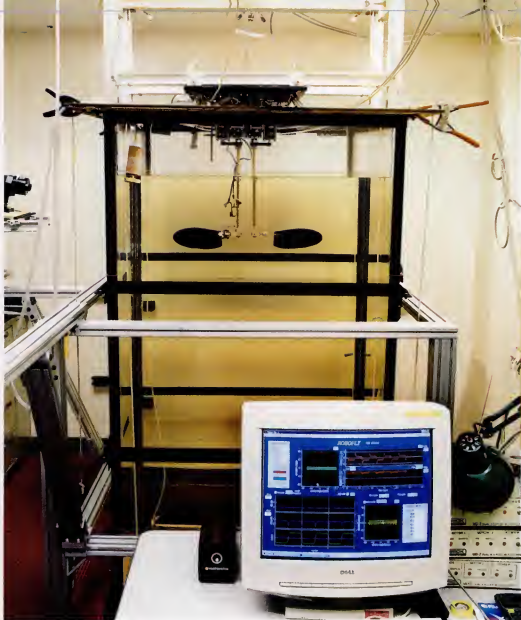
Dickinson is a small 39-year-old who wears glasses and sometimes sports a beard thick enough to pass for a mountain man on his frequent hiking trips. He was [\[CONTINUED ON PAGE 34\]](#) ►

SMELL-O-VISION

How do odors affect flight behavior?

Inside this flight simulator for flies, thousands of light-emitting diodes fool a tethered fly (at center) into thinking that it’s flying freely. Dickinson and his students measure how the animal’s flight patterns are affected by odors.

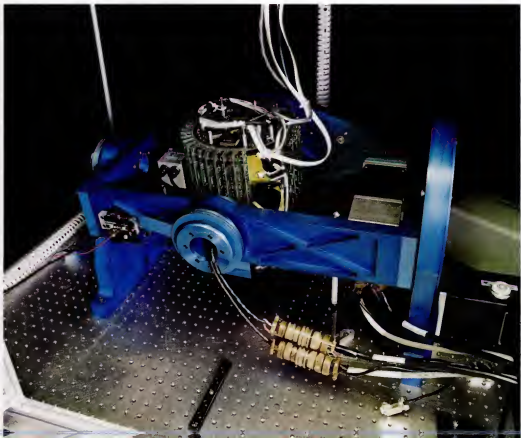




ROBOFLY

How do flies get around?

Dickinson and colleagues study the aerodynamics of insect flight by pumping bubbles into this tank of mineral oil, then watching how the oil flows around two plastic blades (inset below) that simulate the wings of flies (sometimes they use just one blade). Sensors record the forces acting upon the larger-than-life wings.



FLY-O-RAMA

How do flies chart a path?

Dickinson's team uses this simulator, which has a stereo video system, to learn how flies "fuse" information from their surroundings to make decisions about which direction to fly in, when to turn and where to land.

ROCK-AND-ROLL FLY ARENA

How do flies steer?

This "virtual reality" arena is mounted on a gimbal, allowing researchers to study how flies use their natural gyroscopes to steer in response to shifting patterns of lights on the wall.

Wakes, vortices and the leading edge

THE COMMON FRUIT FLY, *Drosophila melanogaster*, uses some ingenious methods to keep its tiny body aloft. Whereas an airplane wing is a relatively simple system, remaining in a fixed position during flight, the frantic back-and-forth movement of an insect wing creates unique aerodynamic efficiencies that are not found anywhere else in nature. Exploiting those efficiencies may lead to the development of tiny robots with the power and control of an insect in flight.



DELAYED STALL

During a wing stroke, a vortex of air (yellow arrows) forms above and behind the wing's leading edge. The vortex lowers air pressure and increases lift (red arrows). Before it can detach, causing a stall, the wings rotate and begin a new stroke.

WAKE CAPTURE

As a fly's wing moves forward, it leaves behind a wake of swirling air. When the wing reverses direction, it pushes off from the swirling air, which provides lift.



ROTATIONAL LIFT

At the end of the forward stroke, the fly is moving ahead while its wings rotate backward 90 degrees. The rotation deflects air downward, which in turn creates an upward lift.

Caught on Tape

Dickinson's team records the rapid wing movements of a captured fly with ultra-high-speed digital video cameras. The cameras capture 5,000 frames per second (compare that with the 24 frames-per-second rate of typical movies).



DELAYED STALL

WINGS In addition to creating lift, a fly's wings also serve as tongues, sensing the chemical composition of adjacent objects.

HALTERES These small organs function as gyroscopes as they beat back and forth in time with the wings during flight.

EYES Each compound eye has about 600 "facets," which give the insect a 270-degree panoramic view.

ABDOMEN A female fruit fly is able to hover even when her abdomen is swollen to twice normal size with eggs.

LEGS Tucked under the body during flight, they extend like landing gear just before touchdown.

What Is Lift?

Lift is one of the most commonly misunderstood ideas in science. Many people have been taught that an airplane's lift is caused by air traveling faster over the top of the wing than the bottom: The faster air is less dense, and that density difference pushes the plane upward. That explanation is close (differences in air pressure do create lift), but not generally correct. Lift occurs when a solid surface—a wing, for instance—travels

through a fluid (or gas) and deflects the flow of the fluid downward. Engineers call this phenomenon "turning" the fluid. Because every action must

have an equal and opposite reaction, the downward thrust of the fluid must be accompanied by an equivalent upward force on the wing. Net result: Air is deflected down, the wing is pushed up and the plane stays aloft.



ROTATIONAL LIFT

WAKE CAPTURE

introduced to flies in the mid-1980s, when he was at the University of Washington getting his Ph.D. in neurobiology. Fruit flies are the guinea pig of this field, because they have only about 500,000 neurons—compared with 100 billion in a human brain. A fly uses most of those neurons to gather sensory information, including light with its eyes, smells with odor-sensitive hairs, and balance with club-shaped gyroscopes behind the wings. Those signals get funneled through the nervous system, which then sends commands to the wings. The commands have to be simple yet exquisitely precise, because the time between wing beats is only a few thousandths of a second.

As a graduate student, Dickinson studied the natural strain gauges on flies' wings that help them sense how much their wings are bending. But along the way, something began to bother him. "How can I understand what the sensors on a fly wing are used for if I don't understand the forces a wing encounters?" he wondered.

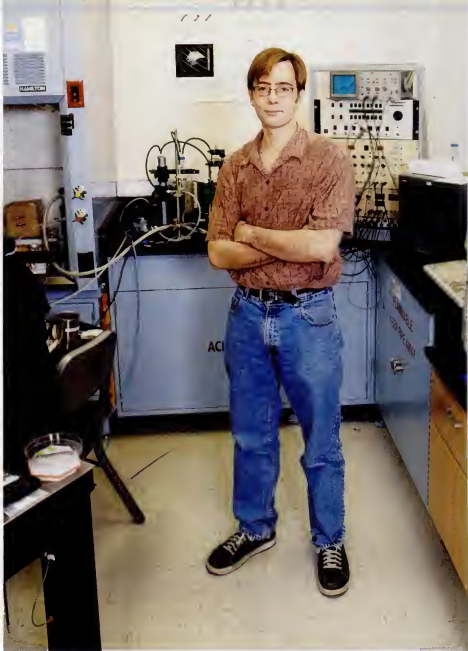
For decades, scientists had been attempting to do just that by testing models of insect wings in wind tunnels. But in 1984, biologist Charles Ellington of the University of Cambridge examined the measurements that had been amassed and found that the numbers didn't add up. No one had managed to explain even half of the lift that insects actually create. Since then, researchers have proposed a host of ways in which insects could be invisibly adding lift to their flight. Evaluating these theories has been impossible, though, because there are simply too many variables to consider: "No computer on the planet could tell us what the forces are," says Dickinson. He decided to take a different approach: "Let's just measure it."

Dickinson knew he couldn't measure the forces at work on a living insect in flight: Even the smallest man-made sensors couldn't fit on a fly's wing. So he decided to use a mechanical fly instead. The tricky part would be to make it experience the same forces a fly does. Air behaves very differently around an insect than around a large animal. To us, it's delicate and slippery. But on the scale of fruit flies, it's thick and sticky.

Working with Karl Götz at the Max Planck Institute for Biological Cybernetics in Germany, Dickinson created his first robotic wing. He found that a 2-inch-wide wing flapping in sugar syrup would experience the same forces that a much smaller fruit fly wing does in the air. Dickinson and Götz built the wing and designed a simple computer-controlled motor to make it flap back and forth. As the sensor-laden wing waved through the syrup, they flooded the tank with aluminum shav-

THE FLY MAN

Michael Dickinson is fascinated by flies because they look so simple yet are able to perform incredible aerial feats.



ings. They then took video footage of the swirling shavings and compared it with the forces recorded by the sensors.

A fly, Dickinson discovered, uses a number of tricks to generate lift. One trick involves keeping its wings at steep angles. Instead of gliding smoothly over the wing, the upper stream of air forms a swirling vortex along the wing's leading edge. This vortex lowers the air pressure above the wing, providing an extra upward boost.

Any pilot can tell you that tilting your wings at a steep angle is a risky strategy. The more steeply an airplane climbs, the harder it is for the stream of air traveling over the top of a wing to stay attached to the wing's edge. When the stream pulls away altogether, the plane loses its lift and stalls. But flies have an advantage over planes: They don't have to hold their wings in a fixed position. A fly flaps its wings back and forth so quickly that the vortex at the wing's leading edge doesn't have time to detach before the wings finish a stroke. At the end of each stroke, the fly rotates its wings so that it can flap them in the reverse direction. This creates a new vortex, while the old one slips off harmlessly—without causing a stall.

Later experiments with Robofly, whose wingspan measures 25 inches, revealed a second source of lift, which comes as a fly

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rotates its wings between strokes. A rotating object (such as a tennis ball hit with backspin) pulls air over its top surface, which reduces air pressure above the object, and pushes air in the opposite direction below, increasing air pressure there. This rotational force, which is also generated as a fly flaps its wings, can supply the insect with up to a third of its entire lift.

A fly can also generate lift from its own wake. When it sheds a vortex from its wings at the end of each stroke, the vortex drifts slowly away, still spinning. As the insect brings its wings back through the next stroke, Dickinson found, the wake pushes against the wings and lifts them up.

As Dickinson decrypted the physics of insect flight, he found himself drawn into the company of people who build robots. Recently he helped his Berkeley colleague Fearing create the Micromechanical Flying Insect, a blowfly-like device less than an inch long that's being developed with funding from the Office of Naval Research and the Defense Advanced Research Projects Agency. So far, though, the robotic blowfly has only flown on a tether, and with just one wing. The main limiting factor, says Dickinson, is the battery, which is currently too large and too weak to make extended flight a reality.

Dickinson's interest in robotics is as a biologist; he doesn't aspire to be the next Orville Wright. He looks at flying devices as an opportunity to evaluate his notions about how animals function. "In biology, it's rare that you have the opportunity to test your ideas by building something," he says.

It travels around an arena decorated with a random collection of white and black squares, sending what it sees to a computer. The computer uses Dickinson's rules to choose where to go next. Dickinson hopes that it will make decisions to turn the way flies do. "It's fine to make a diagram, but to actually build something you really have to put your money where your mouth is." If he's right, the camera will take the same flight path as a real fly. If not, it may crash into a wall.

Ultimately Dickinson hopes to take everything he's learned about how flies fly and apply it to an even bigger question: how insect flight evolved. Insects probably developed wings from body scales more than 300 million years ago. Wings were the secret to their success—flying insects make up the vast majority of all known animal species on Earth. Since the origin of flight, insects have fine-tuned their anatomy to accommodate a range of flying styles, from the broad gliding wings of dragonflies to the fierce fighter-jet attacks of wasps. "You have to understand the mechanism before you can understand how behavior evolves," says Dickinson.

But it is hard for Dickinson to imagine the day when he will have answered all his questions. "The more we study fly flight, the more we realize how little we understand," he says.

A case in point: After making the rounds to see how his students are doing, Dickinson comes back to his office, where Mark Frye, a post-doctoral fellow in the lab, wants his help. Frye is writing a computer program to simulate an airborne

"It's fine to make a diagram, but to actually build something you really have to put your money where your mouth is."



Dickinson recently moved his lab to the California Institute of Technology in Pasadena, where he and his students are continuing to develop machines to study insect flight, such as the Rock-and-Roll Fly Arena, a flight simulator for fruit flies. The arena is a hollow cylinder 6 inches in diameter; 12,000 light-emitting diodes line its inner wall. Dickinson's team glues a fly to the tip of a steel rod at the center of the arena, leaving its wings unhampered. The wall surrounding the fly lights up in a shifting pattern of bars and boxes that tricks the fly into believing it is flying freely in an arena.

As the fly tries to turn, a camera detects the changes in wing motion and feeds that information to a computer, which quickly alters the lights on the wall. The fly "thinks" that it's really turning, to steer clear of an obstruction. The "Rock-and-Roll" part of the arena's name comes from the way the entire simulator can pitch and yaw, letting Dickinson and his students study how flies use their gyroscopes to steer.

The arena has helped Dickinson's team develop a set of rules that they think govern how flies maneuver. As a fly moves toward an object, the object grows larger in its eyes. If it grows bigger in one eye than another, the fly turns to avoid it; if it expands directly in front, the fly stretches out its legs to land. To test that theory, Dickinson and his students have built a machine called Flyball (think eyeball).

Flyball consists of a video camera mounted on a system of

fruit fly—essentially a dry run for Flyball. The simulated fly takes a path through a simulated arena, using the decision rules the team has put together. But it's not working.

"If I only let them turn in one direction, it works great," Frye says. But if he lets the simulated flies choose which way to turn, the results go haywire.

Dickinson offers some suggestions—perhaps make the insect respond not just to what's right in front of it but also to what it saw a few moments earlier. They try to work out how Frye might turn that into a program, and after a while they fall silent, both a little exasperated. Then Frye utters three words that are something of a motto of Dickinson's team, and often can be found scribbled on blackboards around the lab:

"Little [expletive] robots."

Dickinson smiles and repeats the sentiment: "Little [expletive] robots." These apparently simple creatures that, neurologically speaking, amount to little more than a few circuits, still manage to confound him at every pass. But in truth Dickinson's motto is a term of affection. "Flies are wondrous things," he says. "Probably every human on the planet sees at least one fly a day, and yet we don't even notice them. Right under our noses are these extraordinary little machines." ■

Carl Zimmer's books include Evolution: The Triumph of an Idea. He's currently at work on a book about the origins of neurology in the 1600s.

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MASSIVE



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THE
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HISTORY,
A PRODUCT
OF THE
DIGITAL
DARK
ARTS.
BY
DAN
KOEPEL

ATTACK



AGENTS OF DESTRUCTION:
Thousands of digitally created
fighters clash with humanity in the
Battle of Helm's Deep, below.
Right: A Massive agent uncloaked.



// A HOST OF DARK
SHAPES POURED IN...
A HUNDRED LADDERS
WERE RAISED AGAINST
THE BATTLEMENTS.
OVER THE WALL AND
UNDER THE WALL,
THE LAST ASSAULT
CAME SWEEPING
IN LIKE A

**DARK
WAVE
UPON A
HILL OF
SAND."**

—THE TWO TOWERS, J.R.R. TOLKIEN, 1931

IN DECEMBER VAST HORDES OF EAGER FILMGOERS will mob cineplexes across the land and witness, at the climax of *The Two Towers*, one of the most anticipated scenes in recent movie history: the great Battle of Helm's Deep. *The Two Towers* is the second film in Peter Jackson's audacious and, so far, triumphant *Lord of the Rings* trilogy (the films are being released by New Line Cinema, which, like POPULAR SCIENCE, is owned by AOL Time Warner). In this installment, the action takes a darker turn: Humanity and its ragtag allies engage the monstrous forces that would dominate Middle Earth. Humans, hobbits, wizards, dwarves and elves are called to arms against Orcs, Ringwraiths and their awful legion of followers—some 50,000 fighters on the ground, all but the relatively small number of main characters computer-generated. The battle rages across the foot of a great mountain range. Lightning flashes and rain pounds the nighttime spectacle. Fighters skirmish up and down the long ladders that line the fortress walls.

The battle represents a milestone in computer-generated filmmaking. Combat scenes are one of the big challenges of the digital arts, so complicated is the mix of chaos and purposeful action that plays out when soldiers clash in large numbers. Swell the number to thousands and make each fighter appear autonomous onscreen: That was the gauntlet Jackson

threw down to his programmers, and if they have pulled it off this will be the most spectacular CG scene ever. Needless to say, new technology was required.

"Our perception of characters is very sharp, which makes it all the more difficult to get the subtle details of artificial life forms believable," says Karl Sims, a former MIT researcher whose 1994 paper, "Evolving Virtual Creatures," outlined the key challenge that digital animators grapple with. Human (and humanoid) forms represent the highest order of CG simulation because audiences are trained since birth to track human movement in all its complexity. So far, Sims says, filmmakers have done better with smaller creatures: "Even swarms of insects are easier to simulate than humans."

Until recently, relatively simple simulations of physical interactions have driven digital crowd sequences. Using basic rules governing attraction and repulsion, designers aimed single points called particles at each other. Each particle represents a different individual, and when a satisfactory mix is achieved to portray the movements of a group or crowd, animation is added: The particle is rendered as a digital human or creature. The result is cost-effective but not always natural-looking; particle trajectories emulate pool-table-level physics across a two-dimensional space. The movement of real people, especially in battle over rough terrain, is a hugely more complex challenge for the programmer.

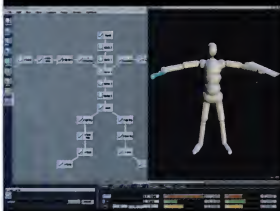
Peter Jackson, shooting his films in the unlikely, un-Hollywood setting of New Zealand, favored a different approach. Jackson had already shown his maverick style in his effects-rich 1996 poltergeist film, *The Frighteners*. For the film's effects, he employed WETA, a sort of Kiwi upstart version of George Lucas's Industrial Light and Magic that Jackson began in 1993. In 1996, he asked fellow New Zealander Stephen Regelous, who had worked as a technical director on *The Frighteners*, to become the crowds supervisor (a digital wrangler in the service of Jackson's Cecil B. DeMille vision) for *The Fellowship of the Ring*, the film that launched the trilogy. Influenced by artificial life theorists like MIT's Sims, and a student of medieval battles, Regelous spent the next several years writing Massive, a software program that generates crowds whose interaction is based not on particle dynamics but on unique and unpredictable choices made by individual characters within a scene. Rather than concentrating on duplicating mechanical actions, Massive endows each character with a digital brain and gives it the power to act completely on its own. In an AI sense, the characters fighting in Helm's Deep are, well, *fighting*.

This approach means much less reliance on cutting and pasting (the initially impressive Colosseum crowd in *Gladiator* was made by duplicating and digitally tweaking 200 human extras; viewed carefully, the carbon copy spectators can create a disconcerting effect). Massive was built on the understanding that the believability of a cast of thousands depends on the actions of individuals. "If [one Orc] acts naturally," Regelous says, "so will the group."

When Orc meets elf in digital battle, neither knows exactly what he—or his opponent—is going to do. The elf may swing his sword, but when? His opponent will see it and duck (or not, and not). The elf jumps forward. The Orc cowers—and this time, the elf's blow finds bone. While the result of the whole battle is broadly predetermined—there is a plot—individual sequences have what might be called programmed spontaneity. Each movement emerges from the one before it.

IF HE ONLY HAD A BRAIN

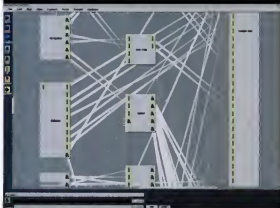
TO CREATE A 50,000-STRONG MOB OF INTELLIGENT DIGITAL WARRIORS, MASSIVE CREATOR STEPHEN REGELOUS BUILDS EACH AGENT PIECE BY PIECE, IMPLANTING A DIGITAL BRAIN INTO A RENDERED BODY. THEN HE REPLICATES AND TWEAKS THE AGENTS. IN A SCENE, AGENTS MAKE DECISIONS BASED ON THEIR ABILITIES—AND ON WHAT'S HAPPENING AROUND THEM.



1

BUILD THE AGENT

Massive agents begin life rendered as three-dimensional characters, not the stick figures of older software. Each body part has a size and a weight that obeys the laws of physics—as, for example, when the agent is beheaded and topples off a 50-foot ladder.



3

CREATE THE BRAIN

The core of every agent is its brain, a network of thousands of interconnected logic nodes (only a fraction of which are shown here). One group of nodes might represent balance, another the ability to tell friend from foe. The agent's brain relies on fuzzy logic, a kind of artificial intelligence in which values are continuously variable and outcomes intuitive. Massive characters act more like people than like robots.

2

INSERT MOTION

Movement data gleaned from human actors performing in a motion-capture studio is loaded into the Massive program and associated with a skeleton. The programmer can fine-tune the agents' movements using the controls on the bottom of the screen.



4

REPLICATE

When a variety of agents have been developed, copies are created from each blueprint, then the copies are tweaked to give each fighter a unique mix of various characteristics—height, aggressiveness, even dirtiness. The 50,000 characters in the scene will act as individuals. They are placed into a battlefield grid for testing.

5

ATTACK

The simulations begin. Since agents are programmed with tendencies, not specific tasks to accomplish, there is no guarantee they will behave as the director needs them to. Only through a trial-and-error process, in which the characters' programs are constantly adjusted, is the battle scene finalized.



CREATING EVIL: In *The Two Towers*, the evil wizard Saruman breeds legions of fearsome Uruk-Hai fighters, seen below leaving the Orthanc Tower on the way to Helm's Deep. But it takes fuzzy logic and artificial intelligence, not magic, to make the soldiers come to life on screen.

THE DIGITAL CREATURES ARE THEN LEFT TO ACT ON THEIR OWN. AN ACTION SCENE ASSEMBLES ITSELF.

Massive characters, or "agents," function as complex beings subject to physical forces, with specific body attributes that range from the biological (short, good eyesight, dark skin) to the behavioral (aggressive). These features govern a Massive character's ability to generate credible motion. Each character is assigned a host of potential actions, as many as 350, each about a second long (sword up, sword down, step forward, step back). How these actions play out is determined by the character's brain, a tangled web of anywhere from 100 to 8,000 behavioral logic nodes, which provide the rules that allow each character to perceive, interpret and respond to what's happening around it: to make decisions and act. These nodes group into rule collections which control aggression, fighting style, movement across varied terrain, and a dozen other factors. Regelous originally tried to use pen and paper to sketch the relationships between nodes in a character. "It got chaotic very fast," he says, and Massive designers now use a special graphical user interface to connect nodes and create an agent's brain. A fully formed character—a map of its tendencies, its personality, if you will—looks like a huge, multi-dimensional spider web on the screen.

Such a character does not make simple "If A then B" choices. Massive employs fuzzy logic, an alternative logical framework that eschews simple binary signals—the 1's and 0's of traditional computers—for variable data, for an infinite range of algorithmic possibility. Fuzzy logic is needed to support the random and variable events that introduce the element of the unpredictable into digital scenes and make the result, Regelous says, "much more human." A Massive archer

doesn't just hit or miss his target. He adjusts his aim as each arrow follows a slightly different and random trajectory. Success or failure is based on many complex and sometimes interrelated factors, including the skill level he's been programmed with, the weather, and even his mood at the time; but, as in the real world, there's no way to know whether any single shot will be on the mark.

And behavior changes. Massive-generated characters are convincing in part because their inputs come from the digital landscape around them; each has eyes and ears on which it must rely to navigate through battle. At Helm's Deep, when a group of Middle Earth's most fearsome creatures (the mutated Uruk-Hai fighters) advance, they generate a humming sound. The effect is ominous, and the audio cues, Regelous says, also keep the digitally generated creatures from tripping over each other. When one creature comes closer, his humming becomes more distinct, and the next fighter over knows to make room. (This is a digital analog to a technique developed by Jackie Chan, who choreographs onscreen fights by assigning different grunts to his attackers, based on the angle and type of approach; he can "see" them coming, even if his back is turned, based on auditory cues.)



ONCE CREATED, MASSIVE CHARACTERS ARE inserted into unpopulated scenes. The characters are then left to do what they've been created to do, and a battle scene assembles itself. This can take minutes, or overnight, depending on the size and complexity of the scene. Beyond general tendencies, the filmmaker does not know precisely what a character will do, since each is an autonomous and, within the confines of the digital landscape, sentient being. Regelous' laptop still contains an early sequence in which a pair of fighters—an Orc and a human—began a strange dance borne of too-finely balanced combat and obstacle avoidance modules. The digital opponents approach, circle and brandish weapons,

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FOOLING
THE
EYE

POPULAR SCIENCE has cast its eye on movie technology since film's 19th-century beginnings, when we noted (in 1896) that, "In Mr. Edison's kinetoscope, photographs made at each forty-sixth of a second followed one another so quickly under an eyepiece as to fuse with the effect of life and action." The 20th century brought early attempts at special effects: wind machines, for example, and simulations of a sinking ship created without leaving shallow water. In 1927, we described how the Red Sea was parted in the silent version of *The Ten Commandments* (double exposure, reverse motion and a small trough).

Kids who crowd Imax theaters today to watch scenes from the International Space Station will have no inkling that the Cinerama "Super-Movies" hailed at right anticipated the immersive experience by several decades. In 1951, Cinerama employed three projectors and a wrap-around screen eight times the standard size. —BOB SILVERY

but never clash. In another early simulation, Jackson and Regelow watched as several thousand characters fought like hell while, in the background, a small contingent of combatants seemed to think better of it and run away. They weren't programmed to do this. It just happened. "It was spooky," Jackson said in an interview last year.

To avoid surprises, Massive programmers weeded out ineffective agents and duplicated ones that worked. About a dozen initial master characters formed the basic genetic blueprint for more than 50,000 digital creations, which were then individualized by adding random variables such as aggression or happiness. (A few update Tolkien; keep an eye out for a background character in *The Two Towers* who, in the middle of the battle, seems to take a call on his cellphone.)

Despite fuzzy logic and complex node webs, these characters have less brainpower than ants, and the whole battle is a foregone conclusion. The winning team is endowed from the start with the digital DNA needed for victory. Scenes are broken into easier-to-control smaller components, and agents are chosen whose tendencies will draw them into proper continuity. As the software has matured, the movie's technical directors have learned how to tweak agents on the fly, honing movements and responses so that minor flaws in already rendered sequences can be touched up.

IN THE MOVIE, THE ORC ARMY STANDS BEFORE the fortress, pounding spears into the ground. Rain falls, and the darkness is broken only by flashes of lightning reflecting off helmets. The battle begins, and sprawls across the screen until—when all seems lost—an unexpected... no, we're not telling. If Massive has worked its magic well, the story will sweep viewers away and most won't stop to single out the software's more realistic touches. But watch the Orcs climbing ladders: Complex physical move-

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For Your Front Window—p. 13

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ments are a tough trick for point-based digital characters, much easier for Massive creations. "You're going to see hundreds and hundreds of very detailed things like that," Regelow promises. In particle-driven effects, characters rarely walk on rough terrain because it looks awkward. Massive agents are more nimble. (On his laptop, Regelow modifies the landscape as a character moves across it, and the computer-generated stick figure ducks and weaves without hesitation.)

Regelow is hoping the next version of Massive, which he's now showing to U.S. movie studios, will be even more powerful, containing components that allow characters to evolve. In the meantime, other developers are building sophisticated decision-making capabilities into their own digital characters. The arena sequence in the most recent *Star Wars* installment, for example, used artificial intelligence to create individual actions for 30,000 particle-based characters, to good effect; expect further improvements in Episode III. In *Return of the King*, the final film in the *Lord of the Rings* trilogy, the climactic battle—yes, the Battle of Helm's Deep is just a run-up—is rumored to employ more than 100,000 characters.

What audiences will see on December 18 marks another step on the road to creating digital characters that feel so real that viewers can't tell them from their flesh-and-blood Hollywood co-actors, a journey that started two decades ago with *Tron*. "Right now," says artificial life pioneer Karl Sims, "you can still usually tell when something is synthetic. But we'll soon be crossing over into a time where that's not possible. It's going to be a very interesting moment." ■

Dan Koeppel, a film-school dropout, has written for *Wired* and *The New York Times Magazine*. Although a longtime Tolkien reader, he draws the line at *The Silmarillion*.



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GOT TESTOSTERONE?

MODERN MARVELS
BOYS' TOYS
DEC 2ND - 6TH AT 9PM/8C



THE
HISTORY
CHANNEL.

MONDAY
BOND'S GADGETS

TUESDAY
MOTORCYCLES

WEDNESDAY
LIMOS & CONVERTIBLES

THURSDAY
GADGETS & DIGI-TECH

FRIDAY
PRIVATE JETS

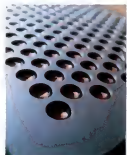
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POPULAR
scienceTOP 100 TECHNOLOGICAL
INNOVATIONS
OF 2002THE
BEST OF
WHAT'S
NEW

ELECTRONICS	48	CARS	54	AUTO TECH	60	AVIATION & SPACE	66
MEDICAL TECH	74	COMPUTERS	78	RECREATION	82		
HOME TECH	86	GENERAL TECH	90	PHOTOGRAPHY	96	INSIDE	

ELECTRONICS

Version 1 of any new technology often leaves raw edges. Next comes the smoothing and polishing, until a technology becomes a boon to use instead of just a wonder to behold. This year, wireless data connections, long agonizingly slow, finally beat dial-up modems. Kenwood and Apple made managing MP3s brainless. Sony ingeniously hid a keyboard beneath a PDA's articulating display. Even our Grand Award winner is a refinement, a trickledown of videophile big-screen, big-money technology—for an affordable price.



SONY CLIE PEG-NX70V PDA

Sony pushes the PDA platform to new heights of form and multimedia function with the Clie PEG-NX70V. Its unique high-resolution screen—320 by 480 pixels and 65,000 colors—pivots up to reveal a keyboard. A 640-by-480-pixel color camera and an MP3 player are also built in. There's even an expansion slot for an optional wireless network card. Price: \$599. www.sonymstyle.com

PIONEER SOUND PROJECTOR

What good is hang-on-the-wall television without hang-on-the-wall surround sound? Pioneer's 37.9 by 25.5 by 5.1-inch Digital Sound Projector, o sound system unlike any other, is made up of 254 2.5-inch speakers that work in concert—using delay patterns—to create 5.1 virtual channels. The result: beams of audio about 2.5 feet wide that seem to envelop you. It sounds as good as it looks. Price: around \$40,000. www.pioneerelectronics.com



PANASONIC COMBO RECORDER

We're not yet predicting the end of the VCR, but Panasonic's DMR-HS2 heads the new product category—combo DVD and hard disk recorder—that, when prices drop, could put tape out to pasture. The DMR-HS2 offers the flexibility of a TiVo, including live-TV pause, and you can record onto DVDs for archiving. It also has a Firewire port for dubbing digital camcorder tapes, PC Card slot for loading stills, and 40GB hard drive that stores 17 hours of video. Price: \$999. www.panasonic.com

15 YEARS OF... GOING DIGITAL

*CD Recorder, 1988

Tandy promised a \$500 CD recorder by 1990, "baffling scientists," noted the *L.A. Times*. Six years later, Pioneer's PDR-09 debuted—for \$4,000. Tandy never delivered.

*Digital Cellphone, 1992

When cellers overloaded analog networks, telcos turned to digital TDMA tech—tripling capacity, reducing static and adding services. Ericsson's DH-197 was the first to support dual-mode (analog and digital) transmissions.

**PDA, 1992

Apple coined the phrase "personal digital assistant" for its Newton Message Pad, which we judged "as easy to use as a pencil and paper." Handwriting software was overhyped, however, and Apple had a Newton bomb on its hands. But it led to the Palm Pilot explosion three years later.

**Digital Satellite TV, 1994

RCA launched DSS, with digital signals from three Hughes satellites captured by 18-inch dishes. Result: 1 million customers in the first 10 months.

*Dolby Digital Sound, 1995

We marveled at the technology (then named AC-3), calling it "true movie theater sound at home." Audio is separated into five channels that envelop the listener, plus a subwoofer for low frequencies. The setup becomes known as 5.1.

*Digital Camcorder, 1995

Sony's DCR-VX1000 Digital Handycam, with a then-revolutionary 410,000-pixel sensor, delivered the highest-quality video ever. The \$4,200 camcorder also incorporated 12-bit audio and a Firewire connection.



1988

1992

1994

1995

[* Best of What's New Winner ** Best of What's New Grand Award Winner]

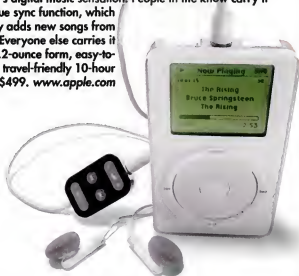


SONY ERICSSON P800

Finally, a U.S. cellphone that'd get a second look in Tokyo. The Sony Ericsson P800 reminds us of the clever and sleek Asian phones, with a large 208-by-320-pixel color display and a built-in digital camera for instant messaging. You can view PowerPoint or Excel files thanks to its Symbian OS, and Bluetooth enables it to swap info with other gadgets. Price depends on carrier. www.sonyericsson.com

APPLE IPOD

The heart of Apple's iPod may be Toshiba's minuscule 20GB hard disk, but it took Apple engineers to turn a portable storage breakthrough into this year's digital music sensation. People in the know carry it for its unique sync function, which automatically adds new songs from your desktop. Everyone else carries it for its svelte 7.2-ounce form, easy-to-use controls and travel-friendly 10-hour battery. Price: \$499. www.apple.com



VKB VIRTUAL KEYBOARD

Meet the keyboard of the future: VKB Inc.'s nifty Virtual Keyboard beams a QWERTY onto the workspace in front of you. Break the light beam and the device registers your keystroke. Licensee Siemens will offer it as a chewing-gum-pack-size PDA accessory early next year, but the technology's greatest promise will come when it's integrated into PDAs and cellphones. Price: \$150. www.vkb.co.il

*Plasma TV, 1997

Futuristic wall-mounted flat-panel TVs became a reality with Fujitsu's 4-inch-thick, 42-inch-diagonal QFIV. Gas plasma sandwiched between glass panels is electrically charged to produce ultraviolet light, made visible by color phosphors. The Fujitsu set cost \$17,500. Today, \$5,000 gets you a 42-inch set.

DVD Player, 1997

No less than 17 DVD players hit the market in late 1997, with the Toshiba SD-2006 leading the charge. The \$599 price was surprisingly reasonable.

HDTV Set, 1998

Zenith shipped the first HDTV with an integrated tuner, but at \$18,600, it was targeted at commercial users. The set featured a wide 16:9 aspect ratio, flat screen and 1,080i resolution, plus Dolby Digital 5.1 theater-quality sound.

*Portable MP3 Player, 1998

MP3 files freed from the PC. We called the Diamond Multimedia Rio PMP300, the first portable MP3 player, a "forerunner of things to come." The Recording Industry Association filed suit to block its introduction, but lost.



*Personal Video Recorder, 1998

ReplayTV's hard-drive-based recorder had live-TV pause. TiVo's version followed in 1999.

*DVD Recorder, 2000

Panasonic's \$4,000 DMRE10 was the first device to record onto a DVD disc—specifically, a DVD-RAM. Still-unreleased format was subsequently delayed the mainstreaming of DVD recorders, with competing DVD-RW and DVD+RW devices arriving in 2001.

Satellite Radio, 2002

Satellite radio, a 2001 Grand Award winner, got a huge jumpstart when GM agreed to offer it in 2003 model-year cars.

1997

1998

2000

2002



PANASONIC eWEAR 4-IN-1

Shattering all the capabilities-per-square-inch records, Panasonic's tiny eWear SV-AV10 is a digital camcorder, digital camcorder, voice recorder and MP3 player. No other combo device matches the SV-AV10's size (3.3 by 1.2 by 2.7 inches), weight (3.5 ounces) or features (2-inch color LCD, SD card storage). Its pictures and video are Web-quality, and its MP3 audio is as good as any other mini-mite out there. Price: \$450. www.panasonic.com

CAPCOM STEEL BATTALION

Capcom takes home-video game immersion to an impressively realistic level with Steel Battalion's arcade-style controller—a wraparound panel with 40 buttons and switches, two joysticks, a slider and three floor pedals. It only works with the Battalion game for Xbox, and it costs a budget-blowing \$200, but for hard-core players there's nothing else like it. www.capcom.com



tech review update

Still a Sonic Marvel?

That's what we called the Bose Wave radio in our 1993 awards. True today? Well, consumers still look at the Wave's fetching form and say, "I like that. I want it." The angling of its speakers enables it to cover a midsize room extremely well. It can play quite loud—at least 90 decibels without distortion—and the tonal balance is pleasingly warm. Midbass response is strong enough to inspire doubletakes: You look at it and wonder if the bass is coming from another planet. Put it on a mid-room coffee table and the Wave will still amaze guests with clean, powerful, musical sound.—MARK FLEISCHMANN



KENWOOD MUSIC KEY

Automotive MP3 players would be much more popular if loading them with music wasn't such a pain. Kenwood's Music Key is the smartest solution we've seen: Its 10GB cartridges hold approximately 2,500 songs.

Every time you sync with your PC via a USB cradle, new music you've downloaded is automatically copied to the Key. It works with any car stereo, operating like a CD changer. Price: \$500. www.kenwoodusa.com

SONY IP220 HANDYCAM

The Sony DCR-IP220 Network Handycam's 2.1-megapixel sensor makes it the first camcorder that takes digital photos worth printing. Its 10X Carl Zeiss optical lens, top-notch image stabilization system and built-in flash make it a true multimedia power tool. Price: \$1,999. www.sonystyle.com

PIONEER PUREVISION PRO-1000HD PLASMA MONITOR

This 50-inch beauty queen, at just 4 inches thick, is the most striking hong-on-the-wall TV we've ever seen. Pioneer boosted brightness 60 percent by making each individual phosphor cell deeper, and improved sharpness by creating tiny walls to prevent cross-pixel contamination. A 160-degree viewing angle lets you enjoy, from anywhere, the best picture \$17,500 can buy. www.pioneerelectronics.com



3G CELLPHONE NETWORKS

With this year's launch of third-generation cellphone networks from Sprint PCS and Verizon, you now may have a speedier Web connection on your cellphone than PC. Both networks connect at 70Kbps, making e-mail, instant messaging and Web surfing legitimate handheld options for the first time. Eventually, speeds will rival DSL. www.sprintpcs.com and www.verizon.com

KYOCERA 7135

The road to a truly usable combo PDA-cellphone was filled with dangerous curves, but this year we finally reached our destination: Kyocera's Smartphone 7135—the first combo that's great at both functions. It comes loaded with Palm applications and supports 3G technology. Price depends on carrier. www.kyocera-wireless.com



TV Stars: Samsung's next-gen big-screen team includes (seated from left) Myung Ryul Jung, Heong Seog Lee, Chang Wan Hong, Ik Sang Kim, Sang Ik Kim; (standing from left) Young Duk Cho, Jin Sik Kim, Jeong Pil Seo, Chang Woo Kang, Kyung Cheol Jang



**GRAND AWARD
WINNER**

**SAMSUNG DLP
HDTV
MONITOR**



Chang Wan Hong arrived at the 2001 International Consumer Electronics Show in Las Vegas feeling pleased. His Samsung team had brought their new Tantus ferroelectric liquid crystal display (FLCD) television. But two days later, after seeing the second-generation digital light processing (DLP) panel that Texas Instruments brought to the show, Steve Panosian, Samsung's senior marketing manager for visual displays, realized there was new competition in town. The advantages of the TI system were obvious: DLP is faster, brighter

and has a higher contrast ratio. Instead of phosphors, which wear out over time, it employs tiny mirrors and a lightbulb.

Hong was dispirited but inspired. By June 2001 his team was working with TI to transform the Tantus into a DLP-based TV; they succeeded in time for this year's Consumer Electronics Show. Samsung's new TV not only offers one of the best pictures available, it does so at a relatively low price: The 43-inch set costs \$3,999. And the unique lens system Hong's team devised bends light in such a way that the TV is a scant 15.7 inches deep. —SUZANNE KANTRA KIRSCHNER



LEAVE IT TO TEXAS TO HANDCRAFT

ITS OWN BRAND OF ***no boundaries***



CARS



We drove some innovative vehicles in 2002, but this won't rank as a year of great leaps forward. (Already we see a hotter 2003, with vehicles from Chrysler, Porsche, Chevy, Volkswagen and others.) That said, Hummer's H2 and Honda's Element goosed the more-of-the-same SUV category. Ford's SVT program proved Detroit can tweak an econo-car into a hot rod. And then there was the return of the Z... Certainly enough to tide us over.



AUDI RS6

It may look like an ordinary sedan, but it moves you like a kick in the pants. Tuned by Quattro GmbH in the spirit of BMW's M5, Audi's all-new RS6 is powered by a 450-horsepower twin-turbo V8 that gets it to 60 mph in 4.6 seconds. Most innovative feature: a tech tidbit called Dynamic Ride Control, a mechanical active suspension that connects the front and rear shocks diagonally with hydraulic lines. It beautifully keeps the 2-ton beast level in corners while soaking up potholes. The RS6 arrives here in limited numbers next July. Price: around \$85,000. www.audiusa.com

HONDA CIVIC HYBRID

By masking its ecofriendly insides with the Civic's standard shell, Honda has transformed the gas-electric drivetrain from an interesting oddity to just another engine option. Yet this option gets 46 mpg in the city while still providing 93 horsepower. Next stop: Mass market acceptance. With a sub-\$20,000 sticker, that's much closer to a done deal. www.honda.com



HONDA ELEMENT

Honda hopes to entice practical-minded young buyers with its funky Element—the most utilitarian sport-utility ever built. The Element's rubber floors can be hosed down, while suicide doors open wide for easy cargo stuffing. There's also a detachable roof for more sun and fun, and four-wheel drive gets you across the occasional dirt road. And how's this for sensible: 23 mpg on the highway and a base price of \$16,000. www.honda.com



15 YEARS OF... OUR AUTO HITS & MISSES

HITS

- Mazda Miata, 1989**
Revival of the sporty roadster: a mere \$13,800 then, \$21K today. Sales only recently waned, despite just one minor redesign in 1998.

- Lexus LS400, 1989**
We wrote that the first-ever Japanese luxury sedan "not only hits the target on the first shot, it's a bull's-eye." Lexus has earned six Best of What's New awards since then.

- Ford Explorer, 1990**
It launched the SUV craze and put the sport in what we'd been calling "four-door utilities" by merging the "ruggedness of an off-roader with the creature comforts of a station wagon."



- Honda Odyssey, 1994**
Honda upped the ante in the minivan revolution with this Accord-based offering. The biggest innovation: The rear seat folds flat. Honda now sells 125,000 yearly in U.S.

MISSES

- Buick Reatta, 1988**
This limited-production luxury two-seater was a dismal failure, despite a novel tunable suspension. Want one? The coupes are now selling for less than \$4,000 an eBay.



- BMW 850i, 1990**
Successor coupe to the 6 Series had a high price and taken rear seat. Bimmer purists stayed away. The pop-up headlights, à la 1986 Honda Accord, didn't help.

- Jaguar XJ220, 1992**
\$750,000, 212-mph supercar was doomed from the start. Jaguar replaced its V12 with a turbo V6. Some customers demanded return of \$70,000 down payments.

- Ford Contour, 1994**
Stateside version of the Mazda "world car" disappointed buyers with its cramped interior and inflated price. Ford dropped it in 2001 to make room for the Escape SUV.



www.fordvehicles.com

HUMMER H2

Here's your half-priced Hummer. The H2 is far more comfortable and civilized than the camouflaged original, but just as skilled when the pavement ends, thanks to an electronic locking rear differential, four-channel antilock brakes and a self-leveling air suspension. And though the 316-horsepower machine drives very much like GM's conventional full-size SUVs, it still impressively climbs 20-inch steps and fords 20-inch-deep streams. And it looks cool. Base price: \$48,065. www.hummer.com



FORD FOCUS SVT

Amazing, the techno-goodies that Ford's Special Vehicles Team was able to squeeze into a stock Focus: 170-horsepower four-cylinder engine, dual-stage intake manifold, variable valve timing, dual-mass flywheel, traction control, six-speed manual transmission. Even heated leather seats are available, as is a sunroof and 290-watt sound system. It's the best of the new sporty hatchbacks. And with prices starting below \$18,000, you'll smile every time you roar past the ATM. www.fordvehicles.com



CADILLAC CTS

The newest Caddy takes aim at the long-loved BMW 3 Series, freshened Mercedes C-Class and much-hyped Jaguar X-Type—and holds its own. We'd like to see V8 power, but the 220-horsepower V6 and world-class suspension conspire to make this the best-handling Cadillac ever. Price: \$29,350. www.cadillac.com



• VW New Beetle, 1998

Retra brilliance. Sire of PT Cruiser, Mini Cooper, T-Bird (all BOWN winners). Weak on power until 2002 Turbo, but VW had sold more than 300,000 through this June.

• Honda Insight, 1999

The first gas-electric hybrid, beating Toyota Prius by 6 months, hit the mark. The electric motor kicks in for acceleration, then recharges by recapturing braking energy.



• Chevrolet Avalanche, 2001

Transformer toy for grown-ups. Composite midgate folds down to turn the SUV into a pickup. The Cadillac EXT and Subaru Baja offer similar versatility. A trend?

• Nissan 350Z, 2002

It's early, but the Z revival looks like a winner to us (see page 58), with one of the best power-to-price ratios on the road. A roadster comes next spring. We can't wait.

• Cadillac Catera, 1996

Weak engine? Dull styling? Disappointing performance? Wiggly duck ads? The Catera was in fact a "new breed of Cadillac"—one that doesn't sell as well as the old breed.

• GM EV1, 1996

Only about 1,100 electric EV1s were leased over four years of production. The 90-mile range didn't help; more important, hybrid technology quickly made it obsolete.

• Oldsmobile Intrigue, 1997

Oldsmobile's last-gasp brand revival did in fact "[compete] with the best of the import sedans," but the competition left it behind in subsequent years. Now it's a lame duck.

• Pontiac Aztek, 2000

We liked the optional rear-end tent and lively 185-horsepower engine. But this is one of the ugliest vehicles in creation and, despite GM protests, doomed.





LINCOLN NAVIGATOR

Respectable handling from a monster sport-utility? It became a reality this year when the Lincoln Navigator got an independent rear suspension—a first for a full-size SUV—and rack and pinion steering. It's packed with other innovations as well, such as a power tailgate, in-dash white LEDs, power folding third-row seat, automatic extending running boards and a speed-dependent rear parking sensor. Prices start at \$48,775. www.lincolnmotors.com



TOYOTA 4RUNNER

The 4Runner incorporates technology you'd never expect to find on a mid-size SUV, including a torque-sensing limited-slip differential; hill descent and stability control; electronic throttle; and rear load-leveling air suspension. Its starter keeps the engine cranking until sensors detect proper combustion in the cylinders, and

90-degree mirrors at the D pillars let the driver see, say, up and down a parking lot aisle while backing up. Pricing starts at just under \$30,000. www.toyota.com

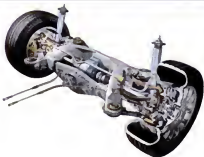
what's missing?

The Cars That Didn't Win

The latest 7 Series reinvents the cockpit. The new Mini Cooper redefines cute. Why aren't they on our 2002 list?

It's quite simple: They won last year. Many new car introductions happen as this issue goes to press. We're able to drive some (often in preproduction form); others aren't yet available. Among the cars we couldn't drive and therefore couldn't consider this year: the Nissan Murano, Porsche Cayenne, Chrysler Crossfire and Pacifica, and Chevy SSR.

Also missing from our list are the first production fuel cell cars from Toyota and Honda, scheduled to hit the streets in California this month. We ultimately decided against them because the "production" run will be tiny, and ordinary consumers won't be able to buy them.



Kodak EasyShare | LS443 zoom digital camera

Schneider-Kreuznach Variogon lens
4.0 megapixels
10x zoom (3x optical, 3.3x advanced digital)
New indoor/outdoor display
Kodak Color Science
Special edition (includes dock)



4.0 megapixels.
And a Schneider lens to make sure
every one of them is put to good use.

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Share Moments. Share Life.™



GRAND AWARD WINNER NISSAN 350Z



The Z Man: Kazutoshi Mizuno and his new machine at Nissan's test center near Phoenix.



To build a car that drives like a Porsche, you turn to someone who knows about speed. Kazutoshi Mizuno, a key player in Nissan's late-'80s Le Mans efforts, has brought lessons learned on the racetrack to the design of the long-awaited 350Z.

Mizuno, 50, has high hopes that the new Z will repeat the success of the blockbuster 1970 240Z, which combined snazz and performance at an irresistible price. The 350Z has a punchy 287-hp 3.5-liter V6 mated to a six-speed gearbox. The performance objective was a sub-6 zero-to-60,

and the car gets there in 5.4 seconds, well into Porsche territory—for under \$30,000, with 26 mpg on the highway.

Its well-balanced 53/47 distribution puts weight on the front tires when turning into a corner, but naturally transfers it rearward during acceleration for a 50/50 split. It has a wide (60.4-inch) track and long (104.3-inch) wheelbase to further reduce pitch, squat and roll. The suspension is mostly aluminum, and "ripple control" shocks dampen small bumps. "The concept of sport driving has been redefined," says Mizuno. "This is the ride of the 21st century."—TED WEST

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NICE
PANTS

AUTOTECH

It's always good to review the fundamentals: That's the lesson from this year's auto-tech advances. Moving back to basics, engineers cooked up a whole new engine configuration and reinvented the steering assembly. Yes, in tough times carmakers focus more on moving metal than on R&D, but 2002 still yielded innovations. New prototypes showed that progress is being made, albeit slowly, on the hybrid and fuel cell front. And our Grand Award winner reimagines the entire automobile from the ground up.



FORD HYDRAULIC HYBRID DRIVE

Ford's "hydraulic launch assist"—unveiled in this Tanka concept in January—takes a decidedly different approach to hybrid design, storing

mechanical energy directly instead of converting it to chemical energy. Hydraulic fluid recaptures braking energy and uses it to pump nitrogen gas into a tank at 5,000 psi. The pressure is released over a turbine, working with the truck's diesel to make 350 hp and 600 pound-feet of torque—with 35 percent better fuel economy. The technology could be useful for super-duty trucks, whose torque requirements would drain batteries quickly. www.fordvehicles.com

CHRYSLER NARIUM FUEL CELL

Attempting to solve the eternal "where do we get the hydrogen?" question—it's difficult to store as a liquid or gas, and metallic hydrides are extremely heavy—Chrysler this year unveiled the most imaginative solution we've seen. Its Natrium minivan is powered by sodium borohydride—essentially, laundry detergent combined with hydrogen. The nonflammable powder gives the Natrium a range of 300 miles. And though it weighs 700 pounds more than a regular Town & Country, Chrysler would shave weight from any production version. www.daimlerchrysler.com



ACURA HIGH-PERFORMANCE HYBRID

The Acura DN-X (and its Honda Dualnote twin, shown), unveiled in April, is a peek at the performance car of the future, with its 3.5-liter

V6 engine supplemented by three electric motors to make 400 horsepower—engineers call it "electric turbocharging." The results: 0 to 60 in less than 5 seconds and 42 miles per gallon. The technology may show up in the next-gen NSX. www.acura.com

15 YEARS OF... SAFETY, POWER & SUSPENSION

SAFETY

POWER

1988 Driver's-side airbags were already common in Europe when the Big Three made them standard in some models in 1988, spurred by a 1990 federal deadline.

****1990** Delco Moraine's affordable antilock braking system, which pumped the brakes by blocking and unblocking the fluid lines, was introduced in Saturns, Pontiacs, Oldsmobiles and Buicks.



***1994** Volvo became the first automaker with side-impact airbags, situated in the seat's side holster (rather than the door panel, which would cave). Other automakers quickly followed.

****1995** After ABS and traction control came stability control. BMW got to market just ahead of Mercedes. Its DSC system compared driver commands to wheels, and corrected under- or oversteer.

***1988** The 1989 Subaru Justy GL was the first production vehicle to get a continuously variable transmission. CVTs provide an infinite number of gear ratios, picked automatically to maximize horsepower.

***1990** The first fully active suspension debuted in Infiniti's Q45. The suspension continually monitored road conditions, sending signals through a computer to adjust shocks and springs and lift tires.

***1990** The key to small, high-power fuel-efficient engines is variable valve timing. Honda introduced it in the 1991 NSX, essentially giving the engine multiple camshafts.



***1990** Porsche's Tiptronic kicked off a wave of hybrid "manumatics" that let you shift manually as well. But the engine overrode gear selection and shifting was still done through a torque converter.

[*Best of What's New Winner **Best of What's New Grand Award Winner]



VW W8 ENGINE

If packing larger power into smaller packages were easy, there'd be no such thing as turbocharging. But with a radically new engine configuration, Volkswagen's W8 squeezes eight cylinders into an engine bay designed for a V6. Its cylinders are arranged like two banks of V's offset by 15 degrees. This allows them to be placed closer together, which in turn lowers the overall length of the engine. The W8 engine adds 80 hp and \$9,000 to the cost of the Passat sedan or wagon. www.vw.com

BMW M3 SEQUENTIAL MANUAL GEARBOX

In a year of new paddle-shift SMGs, BMW's is by far the best. And it's the most flexible we've ever seen: Computers allow the driver to adjust how quickly the hydraulically actuated clutch and gearbox shift. The automatic mode is just as versatile—you can choose from five different shift-point settings, from piddle-about-town to redline. The same computers also control the first automotive Easter egg, a 4,000-rpm launch mode (you'll need to request the European-spec software). The gearbox was introduced early this year in the 2002 M3, which starts at \$47,195. www.bmwusa.com



• **1997** The National Highway Traffic Safety Administration approved depowered airbags, which deploy with 20 to 35 percent less force to protect children. Occupant-sensing bags arrive in 1999.

• **1998** Run-flat tires were not used on conventional wheels until the Firehawk SH30 RFT. With a special rubber compound and sidewall supports, this tire traveled 50 miles at 55 mph with no pressure.

• **1998** Saab and Volvo separately introduced active head-restraint systems. In Saab's version, violent movement causes the headrest to move up and forward to the head before injury occurs.

• **2002** Mercedes announced it will put its Pre-Safe system (a 2001 winner) in the 2003 S-Class. If a crash is imminent, sensors move seats upright and close the sunroof before impact.



• **1994** Mercedes led the fuel cell charge with its Necar, but only a driver and passenger could squeeze into the fuel-cell-packed transport van. Within two years, the batteries were 80 percent smaller. Necar 5 is a tiny A-Class.



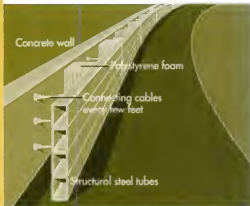
• **1996** Camman-rail diesel fuel injection, developed by Bosch, appeared in European passenger cars from Fiat and Mercedes, prompting a diesel revival across the pond that continues today.

• **2000** The gas-powered Nissan Sentra CA (Clean Air) was the first vehicle to obtain a super-ultra-low-emission vehicle (SULEV) rating—while losing only 4 horsepower from the regular Sentra.

• **2001** 42-watt electrical system debuted on a Siemens and VW prototype. Current 14-watt systems don't have the juice to power by-wire systems. It's still a few years from market.

SAFER RACING BARRIER

After Dale Earnhardt's fatal crash at the 2001 Daytona 500, racing organizations took a new look at an old idea: softer speedway barriers. The result is the Safer (for Steel and Foam Energy Reduction) Barrier, which was



installed for this year's Indianapolis 500. It's the first energy-absorbing longitudinal barrier for high-speed racing, consisting of vertically stacked rectangular steel tubes and up to 14 inches of polystyrene foam, which together absorb more than a third of the energy of impact. Based on its success (four crashes, no serious injuries) at the Indianapolis Motor Speedway, creator Dean Sicking expects the barrier to be installed at every major NASCAR, CART and IRL track within a few years. www.unl.edu

BMW ACTIVE STEERING

The inevitable compromise: Responsive cars are twitchy at speed, while stable high-speed cruisers run slalom like a freight train. BMW Active Steering, demonstrated in prototype this year, takes a revolutionary approach: A planetary gearbox bisects the steering column, allowing a small electric motor to either increase or reduce the steering inputs from the driver. At low speeds (that means below 75 to the Germans), the wheels turn farther for the same steering-wheel displacement, aiding handling. Above 75, the motor runs in reverse, creating less wheel movement and more stability. Expect to see Active Steering on the 2004 5 Series. www.bmwusa.com



Ford's Synthesis Aluminum Car

The Ford Synthesis-2010 earned accolades in 1993, with us calling it the "most extensive study" on the auto use of aluminum. Stronger than steel, aluminum would "lop off about one-third the weight" and "double the fuel efficiency" of a midsize car.

The metal is common today—the average car carries 268 pounds of it, mostly in the engine, transmission, suspension, hood and trunk—but it hasn't lived up to its weight-saving promise, save for in a few high-end cars like the Acura NSX, Audi A8 and Jaguar XJ8. It's much more expensive than steel or iron, and repairing crash damage requires specialized know-how.



High-volume manufacturers now favor high-strength steel for structural applications. The 2003 Mercedes-Benz E-Class is a good example: Mercedes upped the use of high-strength steel from 20 to 36 percent of the car's mass, while increasing aluminum to 10 percent. The result is a strong, light car with excellent performance and safety.

As to what happened to the actual Ford Synthesis-2010 concept vehicle (which also featured a two-stroke engine): It was auctioned in June to a California collector for \$16,000.—DAN CARNEY AND BROOK WILKINSON

CADILLAC'S MAGNETIC SUSPENSION

Occasionally, an idea is so good it deserves two owords. Such is Cadillac's Magnetic Ride Control suspension, which became real this year on the 2002 Seville STS (we cited Delphi for the idea in 1999). The suspension's shock-absorbing liquid, which is a combination of microscopic iron particles and conventional fluid, changes viscosity when exposed to a magnetic field. The change happens without any mechanical valve movement and occurs five times faster than a conventional shock's reaction. The resulting improvement in control is impressive, with the system responding to the wheel's movements hundreds of times per second. The Chevrolet Corvette will get the technology for 2003. www.cadillac.com



CLOCKWISE FROM BOTTOM RIGHT: JASON LEE (2); BRIAN CAHNS



YOU PUT A LOT INTO GETTING YOUR CAR. SPEND A LITTLE MORE TO PROTECT IT.

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GRAND AWARD WINNER GENERAL MOTORS AUTONOMY



Skateboard 2000: GM's Chief of Global Design stands with his Autonomy prototype.



Cars have followed the same design blueprint for so long that it took General Motors' Autonomy concept to remind us that new technology should spur a rethinking of the fundamentals—even in a conservative town like Detroit. Capitalizing on the potential of fuel cells and other new technologies, the Autonomy essentially splits a vehicle into two parts: the mechanicals on the bottom and the usable parts on top. This sounds like a new version of the old chassis/body combination, but it's more than that. Autonomy pushes the car's guts—engine, braking and steering elements, fuel storage,

computer brain—into a 15-foot-long “skateboard” below the feet, leaving everything above this 6-inch platform free for reconfiguration. “With this system, we have total flexibility,” says Chris Bordon-Bird, GM’s 37-year-old head of design and technology fusion. Whether or not the Autonomy concept leads directly to a production car, it is likely to influence automotive design for years to come.

GM originally proposed that “snap-on” bodies could be sold, allowing an owner to have his skateboard-based vehicle changed from, say, a sedan to a minivan as his needs evolved. The strategy has [\[CONTINUED ON PAGE 128\]](#)

art



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AVIATION & SPACE



It was a year of ups and downs for NASA. After five years and two miserable "faster, better, cheaper" project failures, the big news from above was the \$300 million Mars Odyssey's discovery of water. Meanwhile, the agency's new director started work amid questions from observers—including us, in our April issue—about whether NASA had lost its way. On the aviation side, our Grand Award winner made its maiden flight, carrying aloft, yet again, a vision of affordable jet aviation.

LOCKHEED MARTIN ATLAS V

The Atlas V lifted off flawlessly from Cape Canaveral on August 21, carrying a European broadcast satellite and ushering in the era of modular space launch vehicles. The rocket is built with interchangeable parts, so engineers can string components together depending on the size and shape of the payload. The Atlas V can haul as much as 19,000 pounds and is the first U.S. launcher to use a variable-thrust engine, the Russian-built RD-180. www.lockheedmartin.com



NORTHROP GRUMMAN X-47A PEGASUS

If landing a jet on an aircraft carrier is one of the most challenging feats, try designing a robotic fighter to do the same. But that's what Northrop Grumman expects of its X-47A Pegasus, the first unmanned combat air vehicle intended for operations off a carrier. The demonstration craft began low-speed taxi testing on July 19. Next are flight tests to simulate carrier-deck cable arrests. The Navy wants a carrier-based UCAV within 15 years. www.northgrum.com



15 YEARS OF... AVIATION



1988 The Airbus A320 won FAA approval, introducing fly-by-wire controls and side-stick controllers to commercial aviation. The side stick gave pilots an unimpeded view of six CRT displays that replaced dozens of knobs and dials.

***1988** V-22 Osprey, built by Bell and Boeing, took off like a helicopter, then flew as efficiently as a plane using tilting rotors. NASA predicted a major commuter market, but problems and crashes later plagued the project.

***1989** B-2A Stealth Bomber made its first flight, from Edwards Air Force Base in California. The two-pilot subsonic flying wing is made entirely of carbon-graphite composites that absorb radar. Hot exhaust is mixed with cool air before being released. A \$2.2 billion price ultimately prompted the Pentagon to trim order from 132 to only 21 planes. B-2A finally saw combat in 1999 over Kosovo and has flown missions in Afghanistan.



1992 Bombardier stretched its successful Challenger executive jet into the 50-seat commercial Canadair Regional Jet. The CRJ led the way for a new class of short-hop jets whose numbers continue to swell while the major airlines struggle. A 70-passenger CRJ Series 700 followed, with a 90-seat CRJ900 in the works.

***1994** The biggest twin-engine jet ever built, Boeing's 777 employed the first entirely paperless commercial aircraft design. Good thing: The computer-based approach uncovered design flaws that otherwise wouldn't have been noted until an expensive mockup was built.

1988

1989

1992

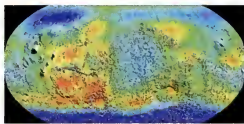
1994

[*Best of What's New Winner / **Best of What's New Grand Award Winner]



BOEING TECHNOLOGY DEMONSTRATOR

Boeing's latest Technology Demonstrator, unveiled in March, offers a peek at how commercial airplanes will navigate the skies in 5, 10 or 15 years. The one-of-a-kind 737-900 boasts a suite of advanced avionics to aid pilots, reduce noise pollution and increase airspace capacity. Some technologies, like a quiet climb system and head-up display, are already in use. Others, like surface guidance and synthetic vision, are still in development. The technologies will first appear in 737s, but Boeing hopes to eventually integrate them across its fleet. www.boeing.com



MARS ODYSSEY

The Mars Odyssey, which reached the Red Planet last October, settled into orbit in February and immediately made an intriguing discovery: Its gamma ray spectrometer found enough ice lurking under the Martian surface (the blue areas above) to fill Lake Michigan twice over—meaning the planet could have once supported life. The spacecraft will continue mapping the chemical composition of Mars' surface until August 2004. mars.jpl.nasa.gov/odyssey



1995 The RQ-1 Predator, the U.S. military's first operational unmanned aerial vehicle (UAV), entered service. Controlled remotely by a pilot and two systems engineers, the General Atomics-built Predator cruises at 229 mph for 32 hours. Cameras and sensors allow all-weather reconnaissance day or night. Predators monitored peacekeeping in Bosnia and spotted targets in Kosovo, and later launched Hellfire missiles near Kabul.

1997 The final-version prototype of Lockheed Martin's F-22 Raptor Advanced Tactical Fighter, the "Superman of fighters" and the Air Force's replacement for the F-15, made its first flight. Recently renamed F/A-22 and due to enter service in 2005 if budget pressures don't delay or ground it, it's the first fighter to integrate data from multiple sensors into a single view for the pilot, and the first to direct multiple radar beams on different targets simultaneously.

2000 Competing Joint Strike Fighter prototypes from Boeing and Lockheed Martin flew. Boeing's X-32 prototype had a gaping air inlet below the nose for 9-G turns: It looked like a fish. Lockheed's X-35 featured revolutionary lift-fan propulsion for VTOL. Lockheed won the \$200 billion contract in 2001, and the JSF should enter service in 2008.

2002 In July, high-speed travel took a giant leap forward when researchers at the University of Queensland in Australia executed the world's first successful flight test of a supersonic combustion engine—a scramjet. The air-breathing engine, dubbed HyShot, flew aboard a rocket launched from a test range in Woomba. It ignited and produced measurable thrust during the final few seconds of the 10-minute flight. Scramjet engines, which could fly at speeds above Mach 8 (5,300 mph), could launch payloads into space at significantly reduced costs.

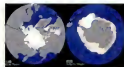
best of what's orbiting

We award three satellites this year not for shedding light on the mysteries of space but for offering a peek into intricate processes at home. They're quite simply the most advanced Earth-observing instruments ever.

ENVISAT, which reached orbit in March, is the largest environmental satellite ever launched, carrying 10 scientific instruments and a multifunctional suite of sensors to provide a simultaneous look at land, oceans and atmosphere, allowing scientists to track all aspects of the Earth environment in real time. envisat.esa.int

NASA's **AQUA**, partner to Terra (a winner in 2000), has been monitoring the global water cycle since May. The satellite tracks the flow of water through the oceans, across ice sheets, into the atmosphere and inside soil. Scientists will use it to study short-term weather patterns and long-term climate changes. aqua.gsfc.nasa.gov

NASA's twin **GRACE** satellites, in orbit 137 miles apart and 310 miles high since March, are measuring minute gravitational variations that pull them together or push them apart. NASA can detect separation changes as small as 10 microns. The goal is to create an accurate map of Earth's gravitational field, so scientists can track changes in Earth's temperature and density—forces that drive tectonic plates and ocean circulation. www.csr.utexas.edu/grace



1995

1997

2000

2002

CONNEXION BY BOEING

Broadband is coming to the friendly skies for the first time thanks to Connexion by Boeing, which received FAA approval this year. The current state-of-the-art is one 56Kbps modem that everyone shores, but Connexion provides up to a 20Mbps wireless pipe back to terra firma and a 1Mbps link to the plane. Lufthansa will inaugurate the service on January 15, with British Airways to follow in February. Pricing will likely be a flat rate, in the \$30 range, for the flight. www.connexionbyboeing.com



AIR SCOOTER

The Air Scooter, invented by Woody Norris (page 94) took a major step closer to production in 2002, when Norris added a light-weight four-stroke engine. Demonstrated exclusively to POPULAR SCIENCE this summer, the craft clocks in just under 254 pounds, qualifying as an ultralight aircraft and thus requiring no pilot license. Norris hopes to begin selling it next year for \$25,000 or so. www.airscooter.com

MENTOR MICRO-AIR VEHICLE

In their quest to build robots that mimic the birds and the bees, scientists haven't yet been able to duplicate the agility of a flying animal. But they took a step closer this year with a February flight in which a flopping robot called Mentor became the first ornithopter to hover. Mentor has four wings and uses tail-like fins for stability. It's

a foot across and weighs about a pound, but its developers hope to shrink it to hummingbird size, which would make it useful for surveillance. www.utas.utoronto.ca/test/res/fm.html



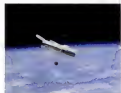
15 YEARS OF... SPACE

A

1988 The U.S., Canada, Japan and Europe agreed to be full partners in the building of an international space station—four years after President Ronald Reagan proposed a 10-year plan to build an \$8 billion station. Later, Russia joined the project.

***1989** Launch of the spacecraft Galileo, bound for Jupiter. Galileo would reach Jupiter in 1995, drop a probe into the gaseous atmosphere, then settle in for years of study. Its mission will end in 2003 with a suicide run through Jupiter's atmosphere.

1990 Shock set in when fuzzy first images revealed a debilitating optical flaw in the Hubble Space Telescope. Failure turned to triumph in 1993 when astronauts repaired the optics. Since then, Hubble has taken more than 350,000 pictures.



***1993** The first of two telescopes comprising the Keck Observatory entered service. Still the largest of such instruments in the world, they have found progressively more distant (and therefore older) objects, helping us understand the universe's beginnings.

****1994** Three planets were discovered orbiting a pulsar (a neutron star) 1,300 light-years away—the first planetary system seen beyond our own. As of press time, 102 planets and 11 multi-planet systems have been confirmed.

***1996** Launch of NASA's first "faster, better, cheaper" mission, the NEAR Shoemaker space probe, which would also become the first spacecraft to orbit and land on an asteroid (Eros). Scientists were surprised to find that Eros is made up of solid rock and littered with boulders. NEAR finally landed on Eros in 2001—taking pictures the whole way down—and collected data for two more weeks.

****1997** On July 4, Mars Pathfinder deployed landing airbags and settled on the Red Planet. A cute, six-wheeled rover ranged over nearby rocks. During the course of three months, the lander-rover duo sent back images, rock and soil analyses and weather data.

***1998** The Russian Zarya module and the American Unity docking hub of the 16-nation, 24-component \$30 billion International Space Station were attached in orbit. The first crew would arrive for a four-month mission in 2000.

****1998** The Deep Space 1 probe headed for comet Borrelly, driven by the first use of solar-powered ion propulsion. The probe's ion engine mysteriously shut down within minutes, but came back

online two weeks later and completed its mission successfully in 2001, testing 12 advanced, high-risk technologies and returning the best images and science data ever from a comet.

2002 August 15 was another bad day for NASA, when the Contour comet probe went silent during its solid-rocket-powered exit from Earth's orbit. Observers later spotted at least two pieces moving where Contour should have been. Plans are afoot for Contour II.





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XCOR XERUS SPACE PLANE

We generally don't give awards to potentially crazy ideas, but the Xerus is the first reusable space-tourist vehicle based on an operating testbed. That testbed, Xcor's EZ-Rocket, officially began its flight program early this year after making several demonstration flights in 2001. It's powered by twin liquid-oxygen-fueled 400-pound-thrust rocket engines. Unveiled in July, Xerus would fly tourists 62 miles high. You can now reserve your 1-hour flight for \$98,000. www.xcor.com



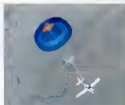
whatever happened to?

Cirrus SR20 Parachute Plane

The SR20 made our list in 1997 and history as we went to press. We cited the aircraft as the first FAA-certified plane ever to come with a parachute designed to bring it to the ground safely after an engine failure or midair collision.

But until this fall, the parachute had never been deployed during an emergency—despite at least four fatal accidents that might have been prevented. In fact, the pilot in a March incident claims to have pulled the activation handle to no avail, and witnesses reported seeing the parachute deploy after the plane hit the ground. But on October 3, near Dallas, 53-year-old Lionel Morrison successfully deployed his parachute after losing a wing flap. He walked away, and the aircraft sustained only minor damage.

With more than 500 SR20 and higher-horsepower SR22 planes in the air, Cirrus has quickly become the number-two light aircraft builder behind Cessna. Ballistic Recovery Systems, which makes Cirrus' parachute system, got FAA approval in September for a Cessna 172 retrofit version. At press time, it had more than 20 orders. —BROOK WILKINSON

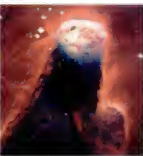


HUBBLE'S NEW CAMERA

The Hubble Space Telescope's view got better in March when astronauts installed the Advanced Camera for Surveys—the most powerful camera ever put into orbit.

Astronomers now have three viewing options: wide angle, zoom and a setting designed to pick up the faintest objects.

Final result? Their power to discover increases by 10, and our wonder continues for a few more years. hubble.stsci.edu



A160 HUMMINGBIRD WARRIOR

This unmanned, experimental helicopter uses innovative rotors to achieve unprecedented range and stamina: Its developers say it will be able to fly more than 2,000 nautical miles without refueling, and stay aloft for more than 24 hours. The main rotor of a conventional helicopter is thin, light and flexible, and it spins at a constant speed to minimize vibration. The Hummingbird, however, has thicker, more rigid blades, and the rotor spins slower when the aircraft slows down to save fuel. In the rear, the smallish tail rotor keeps the helicopter body from spinning. Also, unlike the unmanned airplanes that have played an important role in Afghanistan, the Hummingbird doesn't need an airstrip to take off or land—so it could be used to smuggle unmanned ground vehicles into enemy territory. Built by Frontier Systems of Irvine, California, with funding from the Defense Advanced Research Projects Agency, the A160 demonstrated a brief hover last December and made its first forward flight in January. www.reccce.com



Whoever said getting there is half the fun
didn't have to get there with a three year old.

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GRAND AWARD WINNER ECLIPSE 500 CORPORATE JET

Come Fly With Him: Vern Raburn
and the plane no one thought
he could build.



Back in 1997, aviation experts scoffed at Vern Raburn's plan to build a high-performance twin-engine business jet that would sell for less than \$1 million. What did Raburn know about planes? Before founding Eclipse Aviation, he was a software developer (albeit a good one: He was Microsoft's eighteenth hire). Undaunted, Raburn's team coined a term for their critics' attitude: WCSYC (pronounced *wick-sick*), or "We couldn't, so you can't." When the six-seater Eclipse 500 flew for the first time on August 26, the message to the aviation industry was clear: "You couldn't, but we did."

To achieve his goal of low-cost jet aviation, 52-year-old Raburn adopted new manufacturing techniques, including computer-controlled friction-stir welding, which replaces labor-intensive riveting. His designers went retro with materials, choosing aluminum for structural components rather than the costly, hard-to-produce composites that are currently the rage (Raburn argues they offer no substantial weight or strength advantages). Also critical are the fully computerized avionics and operating systems, which include multiple digital displays in lieu of analog instruments.

Eclipse's secret weapon is [\[CONTINUED ON PAGE 128\]](#) ►

USE

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MEDICAL TECH

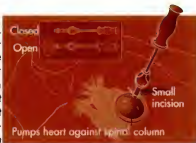
Self-tying sutures, quick-clotting sponges: Many of this year's winners are reminders that, away from the stem cell headlines and blockbuster drugs, progress in medical care happens in a thousand less controversial but important ways. But here's something big to ponder: The Grand Award winner is an animal bred to produce organs for human use.

ORAL SMALLPOX DRUG

Current smallpox drugs require IV injections, making them impossible to distribute quickly. But the first oral smallpox drug, unveiled in March, is 100 times more effective than the injectables, reportedly offering complete protection in 24 hours. It was created by altering the injectable drug to resemble dietary fat. Next step: safety trials. www.ucsd.edu

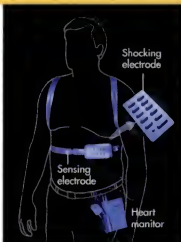


THERACARDIA HEART MASSAGER
Paramedics have two options for cardiac arrest: defibrillation (applicable half the time) or open chest massage (requires big cuts). Enter the Theracardia MID-CM, the first minimally invasive heart massager. The device, which saved six lives during trials this year, enters the chest through a 1.5-inch incision and pumps the heart against the spinal column. Theracardia is seeking funding for further trials. www.theracardia.com



LIFECOR WEARABLE DEFIB

Since its FDA approval in January, the Lifecor LifeVest—the world's first wearable defibrillator—has saved four lives. Designed for patients at high risk for cardiac arrest, the vest detects abnormal heart rhythms by sensing electrical activity on the chest surface. It weighs 3 pounds, but a 1.7-pound version, awaiting approval, is expected soon. www.lifecor.com



Z-MEDICA QUIKLOT

Many victims survive the accident but bleed to death before EMTs arrive. That's the inspiration for QuikClot, the first product outside of the operating room that stops massive bleeding. Approved by the FDA in May, it consists of a mineral sponge that rapidly absorbs all but the blood's clotting factors from an open wound. Troops in Afghanistan have put it to use, and inventor Frank Hursey plans to release a home version by early next year. www.z-medica.com

BIOLOGICAL PACEMAKER

Pacemakers require risky surgery and don't react to the body's signals like normal heart cells. This summer, Eduardo Marbán of Johns Hopkins created the first biological alternative, which could revolutionize the treatment of heart disease. Marbán engineered normal guinea pig heart cells to become pacemaker cells; the results are so promising he hopes to begin human tests in three years. More than 250,000 Americans get pacemakers each year. www.jhu.edu

15 YEARS OF... MEDICAL TECH & RESEARCH

1988 Prozac, first in a new class of antidepressants called selective serotonin reuptake inhibitors, was released to psychiatrists.

1988 Described by Kary B. Mullis three years earlier, polymerase chain reaction began to revolutionize molecular biology by allowing scientists to make millions of copies of DNA quickly. It's now used for everything from DNA fingerprinting and paternity testing to investigation of genetic disease. Mullis was awarded the 1993 Nobel Prize.



1989 Twenty-one-month-old Alyssa Smith received a portion of her mother's liver at the University of Chicago Medical Center—the first living-donor liver transplant. Today, Alyssa leads the life of a typical teen. The procedure has lately come under fire because of risks to the donor, but roughly 1,800 have been done worldwide.



1990 Whole-body positron emission tomography scanning was introduced. Unlike MRI, CT scan and ultrasound, PET senses the chemical activity of a functioning cell in real time, enabling doctors to distinguish between healthy and diseased tissue.

1990 Two children born without the life-sustaining adenosine deaminase enzyme received an injection of genes to produce it. Gene therapy remains experimental, with more than 60 trials under way.

BRAVO ACID REFLUX TEST

Diagnosing gastro-esophageal reflux disease, which afflicts 21 million Americans, traditionally requires a nasal catheter. But in May came Bravo pH, the first catheter-free method. A capsule is inserted into the esophagus, where it transmits data wirelessly to a pager. www.medtronic.com

SONOSITE PORTABLE ULTRASOUND

Emergency responders got a new tool this year: SonoSite's 3-pound iLook, approved by the FDA in June, is the world's first portable ultrasound. The key: SonoSite reduced 20 circuitboards to one. The \$12,000 device could soon change your annual physical too: Looking inside the body is now almost as easy for doctors as checking your heartbeat. www.sonosite.com



LIFEPPOINT 10-DRUG BREATHALYZER

Identifying a driver under the influence is about to get easier. LifePoint's Impact System not only checks for alcohol, but for nine other drugs, including marijuana, cocaine and PCP. It's the first on-site saliva-based test that goes beyond alcohol, providing results in 5 minutes. Introduced in July, Impact mixes saliva with fluorescent chemicals to detect drug and alcohol molecules. Police organizations are now testing the system. Price: \$12,500. www.lifepointinc.com

SELF-TYING SUTURES

Knitting a suture after a minimally invasive surgery requires a skilled surgeon—or a smart suture like

those demonstrated at MIT this spring. When exposed to body heat, the biodegradable shape-memory sutures morph into perfect knots. They could hit the market in 3 years. www.mnemoscience.com



1994 A blood test developed at the Baylor College of Medicine diagnosed a heart attack in 2 hours instead of 12. The \$20 test led to a reduction in unnecessary hospital admissions. Five million Americans visit ERs each year complaining of chest pains, but only 9 percent are actually having a heart attack.

1996 The FDA approved the first antibiotic for treatment of peptic ulcers, vindicating scientists who long believed that some ulcers are caused by *Helicobacter pylori*.

inhibitors—were shown to have potential in turning HIV into a chronic, treatable condition. The treatment has since been so effective that U.S. AIDS deaths have fallen by 71 percent since 1995.

1996 Drug "cocktails"—including nucleoside analogs, protease inhibitors and reverse transcriptase

1998 FDA fast-tracked release of sildenafil citrate. Viagra rapidly became the biggest new in stand-up comedy. Instead of directly causing an erection, Viagra enhances effects of a chemical released in response to sexual stimulation, boosting blood flow to the penis.



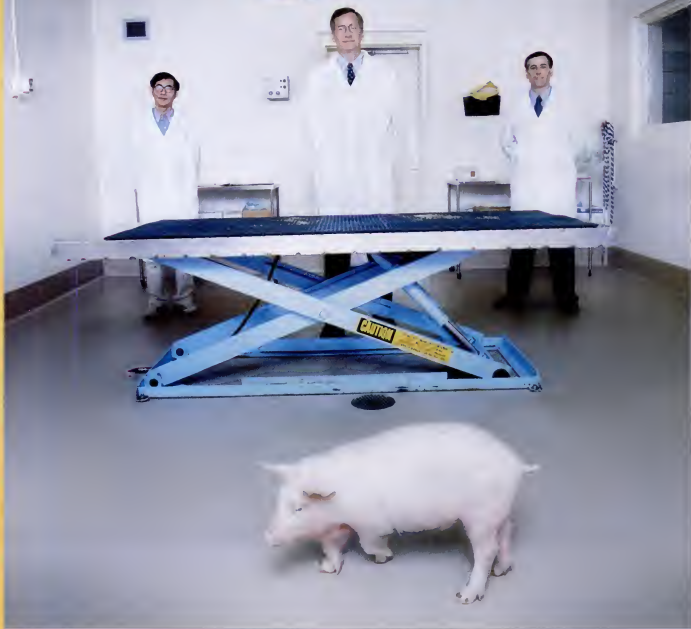
1998 Researchers created human embryonic stem cells—the basic building blocks of the human body—in a lab for the first time, raising the prospect of growing replacement organs and disease-treating cells. The process destroys a human embryo, and this led to fierce public debate about the morality of the practice. In 2001 President Bush put limits on federal funding for research.

2002 Millions of women around the world were alarmed by the release of major long-term population studies showing that hormone replacement therapy is not as effective in preventing disease in certain women as was previously believed.

GRAND AWARD WINNER

IMMERGE KNOCKOUT PIG

Organ Donor of the Future: Fred the pig is the piggy who brought him into the world. Fred is a University of Missouri embryo biologist, Lal and Randall (left and right) are Robert Newkirk.



Randall Prather never imagined pigs like these. No one had. When he was growing up in rural Wisconsin, pigs were raised for meat. But in September 2001, the 43-year-old University of Missouri embryologist and his team crowded into a campus lab to watch the birth of the world's first cloned pigs bred for spare parts; the news went public early this year.

The demand for healthy human hearts, livers and kidneys far exceeds the supply from human donors, and each day in the United States an average of 16 people die waiting. Pig organs, which are roughly the same size as human ones, could provide an alternative. But early test transplants from pigs to monkeys revealed a huge obstacle: The monkeys' immune systems

[\(CONTINUED ON PAGE 128\)](#) ▶

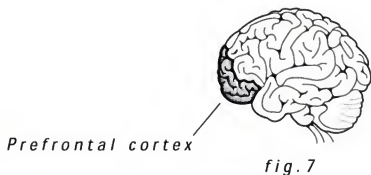
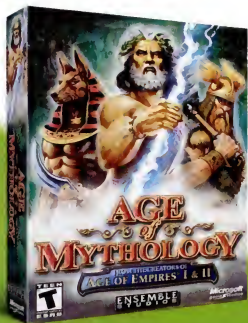


fig. 7



**One essential piece
of equipment for this
game is in your body.**

The other is in your computer.

As your brain's center of anticipation, problem solving and emotional control, your prefrontal cortex will get pushed into overdrive in *Age of Mythology*™. From building majestic temples to joining brave heroes in the great battle of Troy, you'd better have all your wits about you, and you'd better have a PC equipped with the latest NVIDIA® GeForce™ graphics processor. You'd be out of your mind not to, because only NVIDIA delivers the power to unleash the wrath of the gods. So think about this: when the fate of mortal man is in your hands, shouldn't you be playing the game the way it's meant to be played?



Developed on NVIDIA. To be played on NVIDIA.



Age of Mythology and NVIDIA-powered PCs and graphics cards are available at your local CompUSA or at www.gamefixx.com/nvidia/.

COMPUTERS



If you had any doubts that the vanilla-flavor PC is dead, just look at this year's top products—there's not a traditional rig among them. The next frontier is versatility: We award an LCD that doubles as an HDTV monitor, a TiVo-like desktop, and a touchscreen monitor you can use anywhere in the house. The Tablet PC is a whole new take on laptops, and iMac went widescreen. Delicious.



TOSHIBA SATELLITE UXGA DISPLAY



Take a laptop with a really good LCD, put Toshiba's Satellite 5205-S703 with its 15-inch enhanced UXGA display beside it and you'll feel your jaw drop—the difference is that striking. The 1,600- by 1,200-pixel resolution is impressive, but what seals the deal are exceptional brightness (13 percent better than any other LCD), faster response time for smooth DVD movie playback and gaming, and an ultra-wide viewing angle. Price: \$2,699. www.toshiba.com

SAMSUNG SYNCMASTER LCD

Ward files and Web pages by day, DVD movies and TV by night. Samsung's 24-inch SyncMaster 241MP is the first large widescreen LCD monitor that does it all and very well. In work mode, the 1,920- by 1,200-pixel HDTV-capable monitor easily accommodates two applications, or an application and TV, thanks to a built-in NTSC tuner and picture-in-picture support. Or sit back and enjoy the bright, high-contrast (500:1) display with a bunch of friends—it can be viewed at up to 85 degrees off-center. Price: \$4,799. www.samsungusa.com/monitor

15 YEARS OF... COMPUTING

1988 Apple and Quantum Computer Services announced an online service, AppleLink Personal Edition. When Apple balked, Quantum launched it in 1989 as AOL. An MS-DOS version followed. AOL grew big enough to buy Time Warner in 2000.

***1990** The Headstart 300CD, from a division of Philips, became the first PC with a builtin CD-ROM drive. It played music CDs too. Other manufacturers were wary of the format, preferring to stick with then-standard floppies, and initially offered only external CD drives.

1990 NEC introduced the first color-screen portable, the ProSpeed CSX. The LCD screen was so power-hungry that the CSX needed a card, and it was priced at \$8,499—two reasons we didn't award a color laptop until the 1994 Toshiba Portégé.

1990 Researchers at the European Laboratory for Particle Physics tested prototype software that led to the World Wide Web. Initially, it enabled scientists to access a research database via hypertext links.

1991 The JPEG and MPEG compression standards, for still and moving images respectively, brought compatibility—not to mention smaller file sizes—to the confusing world of PC graphics. Named for the committees that designed them (the Joint Photographic and Moving Picture Experts Groups), both standards diminished quality, but imperceptibly.

****1993** Intel's 60MHz Pentium chip upped the PC processing ante, with three times more transistors than the 486. And it could handle two instructions at once. [Today's Pentium 4 is more than 300 times faster than the 8088 chip installed in the original IBM PC.]





VIEWSONIC V150 SMART DISPLAY

Viewsonic's V150 is the first monitor to deliver all the power of your desktop in a remote location. The 5.9-pound 15-inch touchscreen runs Microsoft's Windows CE for Smart Displays, which enables it to receive data from your PC from as far as 300 feet away via an 802.11b link. A 5-hour battery charges in an optional \$200 docking station, so it can serve as your primary monitor as well. Price: \$1,000. www.viewsonic.com



APPLE iMAC G4 WIDESCREEN

Apple's iMac raises the bar yet again with its combination of radical good looks and practicality. It took two years to develop a stainless steel neck that could support a brilliant LCD panel in perfect balance over the iMac's petite 10.6-inch-diameter base, which holds an 800MHz processor and 80GB hard drive. The 17-inch widescreen moves smoothly and easily, halting perfectly steady wherever it's positioned. Price: \$1,999. www.apple.com

TOSHIBA PORTÉGÉ 2010

The supermodel among ultraportables in a year when thin was in, Toshiba's Portégé 2010 is a record-setting 0.73-inch-high slice of magnesium-alloy sex appeal. At 2.6 pounds, it's as easy to carry as a legal pad. It also boasts a crisp 12.1-inch display. Price: \$2,400. www.toshiba.com



JOHN B. CARNETT



MICROSOFT TABLET PC

Ever tried drawing with a mouse? Microsoft's Tablet PC, a radical new take on the laptop computer, lets you use a pen. It has all the functionality of a standard notebook (including a keyboard, either built-in or as a peripheral) plus on electronic stylus for writing on its display with "digital ink." Your handwritten notes can then be edited, translated into text, filed and forwarded. Acer (shown), Hewlett-Packard and others will deliver their own distinctive designs this fall. www.microsoft.com/tabletpc



HEWLETT-PACKARD MEDIA CENTER

As more of our music, photos and videos go digital, it stands to reason that the PC will take on a bigger role in how we experience them. Enter Microsoft's Windows XP Media Edition, an extended version of XP that adds a wireless remote, TiVo-like TV recording and a simple interface you can read from across the room. The first product to incorporate the software is Hewlett-Packard's Media Center PC, which comes with superb Klipsch surround sound speakers, a screaming nVidia graphics card and dedicated audio and video control buttons. Price: \$1,500 to \$2,000. www.hp.com

***1993** Students at the National Center for Supercomputing Applications developed Mosaic, the first cross-platform graphical Web browser. Easy navigation and free distribution helped popularize the Web. Its developers later created Navigator, and Microsoft licensed the technology for Internet Explorer.

1994 Originally called "Jerry and David's Guide to the World Wide Web," Yahoo gave the information superhighway a road map. In the first four months, over 100,000 users logged on.

1995 SyQuest was the name in removable data storage until Iomega came along. Its Zip disks were more compact and cheaper, and Iomega targeted home users looking for a portable hard drive. SyQuest filed for bankruptcy in 1998 and sold its assets to Iomega in 1999.

****1995** "Windows 95 will help millions get started with computers," we predicted, and no question it cemented Microsoft's PC domination. We especially liked its simpler interface, including the Start menu and task bar. It was available on 13 floppies or a CD.

1997 Institute of Electrical and Electronics Engineers ratified 802.11, a standard for wireless local area networks. The standard in use today is alternately called 802.11b or Wi-Fi.

***1999** The most popular of all distributed computing projects, SETI@home, launched. (Distributed computing links computers over the Web to capitalize on unused processing time.) The SETI@home screen saver sifts through radio telescope data. To date, 4 million users have contributed more than 1 million years of computing time. No word yet from ET.

2002 About the time you read this, the first 3GHz computers go on sale. Ironically, *The New York Times* reports the PC market is in a slump because consumers don't need this much speed.

1994



1995

1997

1999

2002

GRAND AWARD
WINNER
IBM METAPAD

The PC in Pincus: Ken Ocheltree (left) and Robert Olyha led the IBM team that created a multi-module PC that includes a head-mounted display and handheld core unit.



Engineer Ken Ocheltree's team at IBM Research in Yorktown Heights, New York, was trying to find a way to shrink a PC to the smallest possible size when they hit on an unconventional idea: Break the computer into mix-and-match components and let users decide how many of them they need at any given time.

The result: a versatile multipart system that they called MetaPad. At its heart is a 9-ounce pocket-size computing unit, about 3 by 5 inches and 1/4-inch thick, consisting of an 800MHz processor, 128MB of memory and a 10GB hard drive. This is the core module; it can be inserted into various functional shells depending on the job at hand. If a PDA suits your purposes, you

[\[CONTINUED ON PAGE 128\]](#) ►



LONGER.

Longer-Lasting Power for High-Tech Devices*

- ▶ Energizer® e² batteries are built with Titanium Technology™ and advanced cell construction so they last longer in your power-hungry, high-tech devices. And the longer they last, the longer you play.

*vs. prior e²; industry standard high-tech tests average



www.energizer-e2.com

RECREATION

With due respect to the advances that come from sports-equipment Goliaths each year—and there are plenty on this list—the most radical innovations, the ones that change how we play, often take shape when someone has a problem, an idea and a workshop. Ten years ago, Christopher Willcox became annoyed with how poorly magnets reproduce electric-guitar sound. This year, his small California startup demonstrated the first optical guitar pickup. Meanwhile, Karl Pope—who takes our top award—brought carbon-fiber technology to surfing with his very cool board. Let's hear it for the Davids.

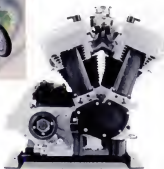
TAYLORMADE R500 SERIES DRIVER

With a sweet spot 100 percent larger than that of any other driver, the R500 is the most powerful and forgiving regulation club ever made. This means 4 mph and 10 yards more on off-center whacks. The secret is on inverted cone welded inside, which varies the face's thickness and enables it to flex as a unit. The R500, which became available to consumers in September, has already won the British Open, PGA and eight other events. Price: \$499. www.taylormadegolf.com



BUELL FIREBOLT XB9R

Domestic motorcycles have been known to be more show than go, but the Buell Firebolt XB9R gives sport-bike riders a machine that does America proud. Its most innovative feature: To shave weight—it's a featherweight at 385 pounds—the oil-aluminum frame doubles as the 3.7-gallon gas tank and its rear swing-arm carries the engine oil. Sounds good, but it's even better on the pavement. The 92-horsepower bike was introduced in July. Price: \$9,995. www.buell.com



FOX RACING TALAS SHOCK

All-mountain riders crave versatility, and Fox Racing Shox's Talas Shock delivers. Introduced this fall on the Trek Liquid series (like the Liquid 20, here), it's the first on-the-fly adjustable suspension system, providing an additional inch of rear-wheel travel in three increments—for a total of 5. You just flick an under-seat lever and two small balls regulate the flow of pressurized oil and air, adjusting the shock. Price: \$510. www.foxracingshox.com





SKI-DOO MX-Z REV

The two-stroke Ski-Doo MX-Z REV reinvents how we ride snowmobiles. Taking a cue from touring motorcycles, the MX-Z seats the rider a full 12 inches forward and on inch higher, with his hips above his knees, and places him closer to the machine's pivot point to isolate him from bumps. Result: easier sit-stand transition, more control in choppy conditions and less pressure on the arms, legs and back. Price: \$7,049 to \$9,199. www.skidoo.com

LIGHTWAVE OPTICAL GUITAR

For the first time in half a century, there's a completely new kind of electric guitar pickup: Light-Wave Systems' optical pickup uses infrared light to cast the string's shadow onto photo-detectors. As the string vibrates, the shadow does too, producing a signal that's turned into sound. The bass strings on our test electro-acoustic rumbled, its high strings wept—both with no feedback or distortion. Look for the guitar in stores next spring. Price not set. www.lightwave-systems.com



MAN OVERBOARD WATCH

Fall into 35°F water and you have 15 minutes: Rescue time is critical. The Guerdion MOB Wristwatch has a small radio transmitter that activates after 4 seconds in water—triggering an alarm of an on-board receiver. And since it transmits on the international rescue frequency, nearby phones and boats will hear the call. Introduced in August, it's also water-resistant to 150 feet. Price: \$995. www.pwss.com

DAINESE MOTORCYCLE AIRBAG

Dainese's D-Air Vest makes it a bit safer to jump on a Hog. Previous motorcycle airbags used a ripcord that could accidentally inflate the bag, but the D-Air works wirelessly. A sensor on the bike continuously tracks movement; if it detects a drastic deceleration, it transmits the "deploy" message to a receiver in the vest. The pressure holds for 20 seconds. The airbag, demonstrated this year, will be available by mid-2003. Price: \$1,500. www.dainese.com



HOW HAS TECHNOLOGY CHANGED YOUR SPORT?

CYCLING

Greg LeMond

3-Time Tour de France Winner

"The aerodynamic handlebar has been the greatest advance in cycling, allowing riders to take a much narrower stance. I was the first to use one, in the 1989 Tour de France; it enabled me to make up a 50-second deficit and win by 8 seconds."



SKIING

Picabo Street

Olympic Gold Medalist

"Technology didn't have much of an effect until parabolic skis arrived. You can corner hard without any effort at all, enabling you to ride a tighter line. But this was a tough adjustment for racers, because it took natural ability out of the equation and made skiing mechanical."

RUNNING

Alberto Salazar

3-Time New York Marathon Champ

"Altitude rooms are a big advance. The gifted athletes from Kenya and Ethiopia live at high altitudes and at 5 years old are running 10 miles to school. Now our runners can sleep in their own beds in an altitude room—at 12,000 feet. We're seeing big differences in their hemoglobin levels."



GOLF

Phil Mickelson

PGA Tour

"The ball goes farther and straighter so we can reach par-5s in two, hit fairways more easily and attack pins. Also, caddies can take and e-mail pictures to your instructor, allowing you get pointers from afar."

DIVING

Fabien Cousteau

Grandson of Jacques

"We need someone to invent a small regulator that harnesses oxygen from the water like a fish does. There'd be no hoses or tank or backpack. Stay underwater long enough and you start thinking about these things."



Nice Two-Pieces: Karl Pope and his carbon-fiber surfing rock star.

GRAND AWARD WINNER HOLLOW CARBON STEALTH SURFBOARD



Karl Pope, the man who built the first surfboard that could be taken apart for easier travel and storage, has outdone himself. His latest invention not only disassembles but is also the strongest, lightest surfboard of its size ever made. Drawing on his experience as an aerospace engineer (he worked on rocket controls at Northrop Aircraft in the 1960s), Pope built the board from carbon fiber, the high strength-to-weight ratio composite favored by airplane designers.

In September Pope sent us his 9-foot 6-inch Hollow Carbon Stealth board—via a Greyhound bus, no small feat

considering a regular surfboard shipped that way would likely arrive damaged. We tested the Stealth the next morning at a quiet San Diego beach in shoulder-high waves. Its weight (at 15 pounds, it's 25 percent lighter than a conventional board made of fiberglass-covered foam) made it easy to maneuver. To see whether it's really 10 times more durable, we repeatedly dropped it on the rocks: No problem.

Pope, 65, who still surfs twice weekly near his home in Ojai, California, says he'd long wanted to build a board out of carbon fiber. But such a board would have to be hollow (solid carbon fiber would be [CONTINUED ON PAGE 130](#) ►)

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photo finish



Enhancing and sharing digital photos is easier than ever with Roxio's PhotoSuite®. Crop out images, get rid of red eye, restore old photos, and then get creative with 360° panoramas and photo mosaics. You can even e-mail customized electronic albums and personalized greeting cards to friends and family. It's easy with the best selling photo editing software in the world. PhotoSuite, from Roxio.



ORGANIZE PHOTOS



ADD EFFECTS



SHARE WITH FAMILY



roxio

HOMETECH

Tool and appliance makers typically innovate at a glacial pace, but this year they brought out their passing game, creating the richest grouping in memory. Dutch Boy smartly reinvented the paint can, while Craftsman reengineered the circular saw. Kelix proved you don't need a compressor to make an air conditioner, and SawStop produced a table saw that won't cut you. Then there's GE, which earns our Grand Award for a full-size range that cooks 5 times faster. What's next? Grills gone wild?

CRAFTSMAN FORCE-MULTIPLYING PLIERS

Squeeze Craftsman's new Switch Pliers and your grip is strengthened as much as eightfold—it's the first plier to incorporate this vise-like capability. An adjustment screw changes the multiplier, so you can use the same squeeze for different jobs. The tool also converts to locking pliers. Price: \$30. www.craftsman.com

DUTCH BOY PAINT CONTAINER

It's the biggest advance in paint since the portable sprayer. Yet it was so obvious. Metal cans are impossible to use without making a mess, so Dutch Boy took a cue from laundry detergent. The 1-gallon plastic Twist & Pour, which arrived in stores in June, includes a similar twist-off lid and a no-drip spout. Sherwin Williams has spent millions converting Dutch Boy to the new container, with stores getting special shakers. It adds a couple of bucks to a gallon of paint. www.dutchboy.com



SWITCHABLE WINDOWS

The first residential smart windows arrived this year, and they're

not electrochromic. In ThermoView's Alter-Lite windows, two panes surround a film embedded with randomly arranged, light-absorbing particles that provide natural shade. When subjected to a voltage, they instantly align to let light pass. Cost: \$100 extra per square foot. www.thermoviewinc.com

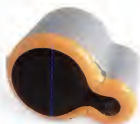
whatever happened to?

The Microwave Clothes Dryer

A prototype microwave clothes dryer developed by the Electric Power Research Institute (EPRI) took our Grand Award in 1994, not only because it dried "in one-third the time" but because it was "gentler on fabrics and can even handle silk and wool." This, from a device that can't cook an egg?

Fast-forward eight years and still no sign of it: Was the microwaved wool being pulled over our eyes? Not exactly. Whirlpool and Maytag considered licensing the technology in 1996, but decided against it.

EPRI has since been working on a smaller, cheaper countertop version for drying small loads in a hurry. Meanwhile, Whirlpool this year demonstrated its own countertop version (seen here) as part of its prototype Plá line for the Gen Y set. It works like EPRI's original concept and can fit two pairs of jeans. But, alas, there are no production plans yet. —JENNY EVERETT



ARBORTECH PLUNGE SAW

It's a tool unlike any we've seen. The Arbortech Allsaw 150 hammer-cuts—that is, its twin blades

plunge with precision into dense materials like brick, masonry, drywall or wood. And their reciprocating action minimizes dust. Teeth at the blade tips make 5-inch plunges possible, while an internal V-belt drive slips them to prevent kickback. The Australian manufacturer demonstrated the tool in the U.S. this summer and hopes to begin selling it here by February. Price: \$580 for the pro version, with a consumer model to follow. www.arbortech.com.au

CLOCKWISE FROM ABOVE: JOHN B. CARRETT; COURTESY OF WHIRLPOOL; STEPHEN FOUNTREE

CRAFTSMAN NO-KICKBACK CIRCULAR SAW

Circular saws have always required a firm grip, but Craftsman's Twin Cutter, demonstrated this year, is the first that prevents kickback. The \$190 tool's two 6-inch blades touch while rotating in opposite directions. The blade forces cancel, eliminating kickback and minimizing vibration. It comes with corbide blades; diamond-tipped are optional. Available in March. www.craftsman.com



SAWSTOP TABLE SAW

More than 3,000 Americans lose a finger to table saws each year, but SawStop promises to ease the carnage. Touching the blade releases a small voltage, stopping the tool in 3 milliseconds. After a failed attempt to license SawStop to tool makers, inventor Stephen Gass unveiled his own 10-inch table saw this year. It goes on sale next spring. www.sawstop.com

KELIX A/C

Imagine a room air conditioner that barely increases your power bill—that's the promise of the first-of-its-kind Kelix Energies concept, unveiled this year. Instead of a power-gulping compressor, it uses a refrigerant-filled coil on a spinning rotor; centrifugal force drives the fluid through the coil, compressing and decompressing it just like a standard evaporator and condenser. Yet it uses just one-tenth the electricity. Kelix hopes to introduce a product within a few years. www.kelix.com

inside view

WE ASKED INDUSTRY EXPERTS: NAME THE KEY TECHNOLOGY ADVANCES OF THE PAST 15 YEARS

Whirlpool: Dishwashers **Andy Wisecup**

"Dishwashers are quieter, use less electricity and water and are 15 percent bigger inside. They also clean better, thanks to soil-detecting sensors."

Jenn-Air: Ranges **Mike Herriot**

"Technologies like convection have cut cooking times in half. Meanwhile, for passionate cooks, magnetic induction ranges offer unprecedented precision, going from boil to simmer instantly."

Carrier: A/C **Frank Hartman**

"Improved exhaust designs and compressor vibration isolators reduced central-air sound levels to 69 decibels—that's the equivalent of a refrigerator."

GE: Lights **Mary Beth Gotti**

"Light emitting diodes promise to change the shape of the lightbulb."

Toro: Pushmowers **Bill Fuelling**

"Demand for lighter, more powerful and easier-to-use mowers prompted innovations like overhead valve engines, self-propulsion and plastic mower housings."

Frigidaire: Fridges **Tony Evans**

"Integrated water filtration systems remove 99 percent of impurities. Many models surpass new federal standards, using less electricity than a 60-watt bulb."

Bosch: Tools **Randall Coe**

"When tools went cordless, batteries lasted only minutes. Now they last hours. The next frontier: durability and longevity, as most cordless tools must be replaced every two to three years."

Sharp: Microwaves **Bob Scaglione**

"Sensors eliminate any guesswork by automatically turning off the microwave when the food is ready."

GRAND AWARD WINNER

GE PROFILE SPEED COOKING OVEN



Hot Property: The GE team (from left) is Phil Barber, Dave Kinny, Larry Portaro, Steve Bakanowski, Leanne Wilks, Jennifer Rael and Coleen Muegge.



Good thing Larry Portaro likes to cook. Five years ago, the General Electric engineer agreed to lead the company's effort to develop a new speed-cooking oven. Some 25,000 cookies, 300 pizzas and 200 turkeys and chickens later, he and his team have unveiled a marvel of culinary efficiency.

Tentatively called the Profile Speed Cooking Oven, it combines bake, broil and microwave components to cook food three to five times faster than a conventional oven. A baked potato takes 17 minutes, a turkey less than 5 per

pound. Fast food is often bad food: Processes like caramelization, in which sugars devolve into a sticky coating, take time—if you apply heat too quickly, the coating turns black. But Portaro, 34, and his team solved that problem. They cooked foods repeatedly, varying the doses of microwave, convective and thermal energy, then programmed into the oven algorithms describing the ideal texture, crispness, moistness and browning for each food type. In July GE gave POPULAR SCIENCE an exclusive demo. Filet mignon, salmon, baked potatoes, chocolate chip

(CONTINUED ON PAGE 130) ►

"WOW, COOL GARAGE"

AND OTHER THINGS PEOPLE NEVER SAY.



Gladiator and It's Time to Rethink the Garage are trademarks of Whirlpool, U.S.A.



"OOH!
A REFRIGERATOR THAT
KEEPS MY SODA FROM
FREEZING IN EXTREME
TEMPERATURES."



"AAH! WALL
CABINETS THAT I
CAN MOVE
AROUND ON THE
GEARWALL™ PANELS."



"YES! FINALLY I
CAN EASILY
MOVE THINGS SO
I CAN CLEAN
MY GARAGE."

FOR A CLOSER
LOOK AT GLADIATOR™
GARAGEWORKS,
VISIT LOWE'S.®



Introducing Gladiator™ GarageWorks by Whirlpool Corporation, the original modular solution that will transform your garage from pit to paradise.

The Modular Workbench System has an 8-foot solid maple top and movable GearDrawers, refrigerator and GearBox. Keep them underneath or roll them out. They work wherever you work. And each piece is built with super-durable, tread-plate steel.

You'll find Gladiator™ GarageWorks at Lowe's® stores. For additional information, call 1-866-342-4089 or visit www.GladiatorGarageWorks.com. Once you do, you'll agree: IT'S TIME TO RETHINK THE GARAGE.™



GENERALTECH



This category presents a grab-bag of technologies but is no less compelling for that. Breathtaking ingenuity is the chief criterion for winning. Take the spectacular Falkirk Wheel, below. It's the first rotating boat lift not because the Scots beat the world to some technological breakthrough but because they were the first to put a gorgeous new spin on an old idea (boat lifts go way back). Take Dean Kamen's much-hyped Segway: Goofy. But the first time you ride it, you understand.

FALKIRK WHEEL

An historic waterway link between the Atlantic Ocean and the North Sea through central Scotland has been revived with the May opening of the \$26 million Falkirk Wheel—the world's first rotating boat lift, connecting the Forth & Clyde and Union canals. The giant hoist's 10 hydraulic motors can lift four boats, water and all, more than 110 feet high in about 15 minutes. While one arm goes up, the other, also carrying four boats, descends. The wheel is located midway between Glasgow and Edinburgh, at the end of a 100-meter-long aqueduct. www.falkirk-wheel.com



15 YEARS OF... BIG ENGINEERING

1988 The \$5.3 billion, 33-mile Seikan Rail Tunnel opened after 24 years of construction, marking the first time Japan's four main islands are linked by land-based transportation. It's still the world's longest rail tunnel.

***1989** The first stadium with a fully retractable roof, the Toronto SkyDome, opened. The 8-acre roof consists of panels that move on 76 steel wheels called "bogie." Each bogie is powered by a 10-horsepower electric motor. Opening time: 20 minutes. SkyDome has since spawned other retractable-roof stadiums.



1991 The biggest civil engineering project in U.S. history, the \$15 billion Boston Central Artery/Tunnel project, or Big Dig, began. The most challenging part: burying parts of I-90 and I-93 under the Fort Point Channel. Just one-tenth of a mile long but costing \$1.5 billion, the crossing is the most expensive highway project per mile in the world. The Big Dig will be completed in 2004.



***1994** After seven years of construction, the Eurotunnel—better known as the Channel—opened, "connecting England with Europe for the first time since the Ice Age." It runs 31 miles, 23 of which are underwater. The average depth is 150 feet under the seabed. Digging was done with the world's largest boring machines. Seven million passengers now travel through the Channel annually. Though the Seikan Rail Tunnel is longer overall, Channel's underwater portion is the world's longest.

1994 Construction of the Chinese Three Gorges Dam, a 20-year, \$24 billion effort to build the world's largest hydroelectric dam, began. Plan called for 575-foot-tall dam a mile across, generating 84 billion kilowatt-hours of power. Reservoir will stretch 350 miles upstream.

1988

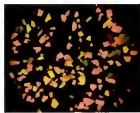
1991

1994

[* Best of What's New Winner ** Best of What's New Grand Award Winner]

BEANTOWN'S NEW ENGINEERING SIGNATURE

In a city steeped in history, Boston's \$86.4 million Leonard P. Zakim Bunker Hill Bridge is making history of its own. The widest cable-stayed bridge in the world, it carries 10 lanes of traffic over the Charles River. It's also the first U.S. hybrid bridge (part steel, part concrete) with an asymmetrical design. The 270-foot-tall bridge, which opened to foot traffic in May (cars in December), is part of Boston's massive Central Artery/Tunnel Project. www.bigdig.com



SMART DUST

Detecting chemical weapons isn't easy, but help is coming in a tiny package. Unveiled in March, "smart dust" is the smallest, most sophisticated chemical sensor ever created. A handful could sniff out thousands of biological and chemical substances at the same time and then be read with a laser akin to a grocery scanner. It might also help scientists monitor atmospheric pollutants. www.ucsd.edu

GOAT-MADE SPIDER SILK

Spider silk is ultrastrong, light, elastic and biodegradable—ideal for everything from surgical sutures to body armor. Unlike silkworms, though, spiders don't take well to animal husbandry. So scientists spliced their genes into goat DNA, producing goats that secrete silk proteins in their milk. BioSteel, as it's called, is the first man-made fiber with spider-silk properties. www.nextbiotech.com



1996 At 1,483 feet, the Petronas Towers in Kuala Lumpur, Malaysia, became the tallest buildings in the world, surpassing Chicago's Sears Tower. Most notable design detail: a 192-foot, 1.65-million-pound sky-bridge connecting the two towers of the 41st floor, 558 feet above the ground. The tallest crown will pass to Taipei Financial Center in 2004.



1998 After 12 years, the longest suspension bridge in the world, the \$4.3 billion Akashi Kaikyo Bridge, opened in Japan, linking Shikoku and Honshu. At 6,570 feet, Akashi Kaikyo's center span is nearly 2,000 feet longer than Britain's Humber Estuary Bridge.

Its 933-foot towers also make it the tallest bridge in the world. A network of trusses below the roadway enable the bridge to withstand hurricanes and 8.5-magnitude earthquakes. Akashi will lose its crown in 2010, when Italy's 10,890-foot Stretto di Messina Bridge, linking Sicily to the mainland, opens.

1998 Hang Kong's new \$20 billion airport opened. The project included a 21-mile railway, a six-lane expressway, two tunnels, two bridges, two islands and high-rise housing. Hang Kong International eliminated one of the most harrowing approaches in aviation: Aircraft flew so low that rumors circulated about snagged high-rise laundry lines.



2002 Reverse engineering on a massive scale: Cleanup of the World Trade Center site ended in June, three months early and at a cost of about \$750 million—less than a tenth the cost originally predicted. 1.8 million tons of rubble were hauled from the 16-acre site to landfills on Staten Island and in New Jersey. Much of the Trade Center's steel will be recycled.

1996

1998

2002

SEGWAY SCOOTER

Dean Kamen's much-hyped invention was unveiled last December, too late for our 2001 awards. Here's the deal: It may not revolutionize human transport, or even your daily commute, but it's a wonderful machine. It seems to read your mind, but really uses tiny forward-backward changes in your body angle to trigger movement, accelerate and stop. Five gyroscopes and two tilt sensors allow the 83-pound scooter to balance itself on a pair of wheels that are independently driven by electric motors. More than 100 commercial Segways are at various stages of testing. The smaller and lighter consumer model, coming next summer, will cost \$3,000. www.segway.com



SIX FLAGS 4-D COASTER

X marks the spot at which you're most likely to lose your lunch. The newest coaster at Six Flags Magic Mountain in Los Angeles, X replaces narrow train cars with 22-foot-wide vehicles that allow riders to spin head-over-heels as they zip along the edge of a twisting track at 76 mph. The vehicles rotate 360 degrees forward or backward, independent of the train's movement. X opened in January, closed temporarily for a few design changes, then reopened in August. www.sixflags.com



whatever happened to?

The Test-Tube Tomato

When USDA biologist Betty Ishida grew her award-winning test-tube cherry tomato in 1992, neither she nor we understood the implications.

Because tomatoes ripen at different speeds, harvesting them is complicated. By finding the ripen-triggering gene, Ishida theorized, tomatoes could be programmed to mature together. But her tomato was odd: Instead of green leaves it had an extra-ripe calyx (star-like structure). Then, in 1995, Ishida learned of a study linking lycopene, a chemical that turns fruit red, to a lowered risk of certain cancers. Sure enough, her calyx had 10 times the usual lycopene. She's redoubled her efforts. A "tomato chip," a slide with thousands of genes etched onto it, will be ready next year, enabling her to see which genes activate under various conditions. "Then we have to get lycopene-rich tomatoes to grow in the field." —WILLIAM G. PHILLIPS



SELF-HEALING MINEFIELD

Unexploded antipersonnel mines (APMs) are a plague in countries from Bosnia to Afghanistan to Cambodia. Triggered by slight pressure, they kill as many as 20,000 civilians each year. The U.S. response to the Ottawa Convention calling for the ban of APMs is to design defensive antitank minefields—using mines that require the heavy pressure of a vehicle—that no longer have an APM component. The so-called Self-Healing Minefield from the Defense Advanced Research Projects Agency—which completed its first phase of testing this year—consists of networked, surface-scattered antitank mines that reposition themselves to fill in breaches. Tiny rocket thrusters or mechanical pistons propel them with 1-meter accuracy.

Other improvements: Operators can deactivate the mines by remote control, and if the mines lose contact they'll self-destruct in 30 days. www.darpa.mil



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a little fun.



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Yeah, You, I'm Talkin' to You: Woody Norris demonstrates his directional HyperSonic Sound device on a Manhattan street corner.

GRAND AWARD WINNER HYPERSONIC SOUND

» Woody Norris has a way of getting inside your head. No, we don't mean his overpowering handshake or Barnumesque penchant for self-promotion ("This is the biggest thing in audio in 77 years"). We mean HyperSonic Sound, his latest creation. (A prolific inventor, Norris, 64, also won a Best of What's New for a personal flying machine—see page 68.)

Unlike traditional speakers, which scatter sound, Norris'

device streams it in a precise, laser-like beam for up to 150 yards with almost no degradation in quality or volume. If that seems incredible, trust me, it is. When I met Norris in September he pointed the 7-inch-square emitter at me from 30 feet away. Suddenly I heard the sound of birds chirping. The noise didn't seem to emanate from his device; I felt like it was generated inside my noggin. Yet a guy just 2 feet away from me couldn't hear it. [\[CONTINUED ON PAGE 130\]](#) ►

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PHOTOGRAPHY

Only one film camera made our list of top models this year. Film isn't going away any time soon, of course, but the digital boom feels like the computer boom of 10 years ago: more power, more models, more features and no end in sight. The high-end cameras mean there's little quality trade-off for everyday use. Printers just keep getting better. And products like our Grand Award winner suggest we ain't seen nothing yet.

NIKON D100

The 6-megapixel barrier fell this year for consumer cameras. Within months, Canon and Nikon shipped the D60 and D100 respectively, both packed with all the features a high-end amateur wants: advanced autofocus, light metering, color temperature modes. Which is best? Tough call. But after two weeks of testing, we gave the edge to the D100 for reproducing more accurate color and better capturing the sparkle of shiny objects. Price: \$2,500. www.nikonusa.com



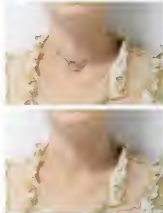
OLYMPUS C-730

Lenses went long this year on compact digital cameras, but at 10X the Olympus C-730 Ultra Zoom went the longest. You wouldn't know it by looking, though: Olympus stashed the lens within an 11.1-ounce body that measures just 4.2 by 3 inches. Another neat touch: Thanks to an auto-connect feature, virtually any PC with a USB port will recognize the 3.2-megapixel camera—no software required. Price: \$699. www.olympus.com



ADOBE PHOTOSHOP 7.0

Software innovation usually wanes after, say, version 3.0, but the seventh version of the richly featured Photoshop program has a tool so amazing, magical even, that we're retouching photos for fun. The Healing Brush turns complex photo manipulation into a one-step process. Below, we copied the skin tone around the neckline, then pasted over it. Photoshop automatically applied the original area's shading, lighting and texture for a perfect match. Price: \$600 (\$149 for the upgrade). www.adobe.com



15 YEARS OF... PHOTOGRAPHY

***1988** Minalta introduced wide-area auto-focus on the Maxum 7000i SLR, enabling cameras to focus on subjects not in the viewfinder's center. Also called multibeam or multi-point autofocus, it's now standard on all cameras.



1988 A year after unveiling the first single-use 35mm camera, Fujifilm introduced the QuickSnap Flash, the first disposable with a built-in flash.

1989 Barney-Scan bundled software called ImagePro with its slide scanners. A year later, Adobe Systems licensed the technology for Photoshop 1.0, its digital image program. With page layout programs, this launched the era of desktop publishing.

1990 Dycam introduced the \$995 Model 1, the first digital camera, with 1MB of memory, enough to store 32 376-by-240-pixel B&W images.

***1991** Kodak introduced the Digital Camera System (DCS) 100, the first pro digital camera. The 55-pound system had a 200MB external hard drive and mona display. For "crisp 1.3-megapixel images," it cost a cool \$30,000.



****1993** Tamron introduced the AF28-200, the first compact lens that could be used in all shooting situations, from wide angle to telephoto. Despite the "remarkable" 7.1X zoom, the lens was only 3.2 inches long and weighed less than a pound.

1994 Epson's Stylus Color Inkjet Printer was the first to produce photo prints good enough for framing. At 720 by 720 dots per inch, it offered double the resolution of any other color inkjet on the market.

1988

1989

1990

1991

1993

1994



NIKON COOLPIX 5700

With a superb 8X optical zoom lens, Nikon's Coolpix 5700 is the coolest of this year's digital SLRs. And it knows what to do with those long shots: The 5-megapixel sensor is capable of studio-quality prints up to 16 by 20 inches. Neatest feature: Its "best shot selector" automatically selects the sharpest picture from a series of consecutive shots. Price: \$1,199. www.nikanusa.com



HP PHOTOSMART 7550

Photo printers got one step closer to 1-hour-photoblob convenience this year with Hewlett-Packard's Photosmart 7550. You can plug your camera right into the printer's USB port, or pop virtually any type of memory card into its front slot. You can also preview and edit your photos on a color LCD. Even 4 by 6 borderless printing is a snap thanks to a dedicated paper slot. And with seven ink cartridges, you get stunning photos. Price: \$399. www.hp.com

MINOLTA DIMAGE Xi

With Minolta's DiMAGE Xi, there's no need to choose between size and sizzle. It's the first pocketable camera with a full set of out-of-pocket features: 3X optical zoom, built-in flash, 1.5-inch LCD and 3.2-megapixel sensor. And the zoom never pokes out side the sleek metallic body, thanks to a unique vertical lens system. Price: \$499. www.minolta.com



***1995** Casio's QV10 was the first digital camera with a built-in LCD, enabling photographers to preview and review their shots on a 1.8-inch-diagonal screen.

"You can enlarge stored pictures," we marveled, "or delete them on the fly." The \$899 camera stored 96 color stills.

***1996** A slew of Advanced Photo System (APS) cameras hit the market, led by Canon's Elph, the world's smallest and lightest 2X zoom camera. APS was designed to simplify photography by offering multiple print sizes and foolproof film loading. But APS resolution is lower than 35mm film [see page 98].

****1997** Olympus' 1.4-megapixel D-600L SLR and Kodak's 1-megapixel DC 210 point-and-shoot cameras launched two days apart, sounding the starting gun of the more-megapixel race. Both cameras earned our accolades, with the Olympus taking the Grand Award because it brought "the control of a 35mm to an affordable digital."



***1997** The Sony Mavica MVC-FD5 and MVC-FD7 stored as many as 40 color photos on a 3.5-inch floppy, making the camera-to-PC connection a cinch. The Mavicas dominated the market briefly until USB and Firewire made file sharing ultra-easy.

****2002** Just when you thought digital image quality couldn't get better, Foreman comes along with the X3 image sensor, which changes the way digital cameras detect color. Using silicon as a color separator, the sensor captures red, green and blue at each pixel, eliminating interpolation [see page 100].

***1998** PopSci went digital with Kodak's 2-megapixel DCS 520; it shot every photo in that year's BOWN section except one—itsself.



1995

1996

1997

1998

2002



LOGITECH POCKET DIGITAL

Pocket-size digitals are finally living up to the name, and Logitech's is the best of this year's bunch. The size of a credit card, and not much thicker, the tiny snapper has neither a flash nor zoom, and its 1-mega-pixel resolution is best suited for e-mailing. With this pull-apart beauty, there's no excuse for leaving the camera at home. You might even forget which pocket you put it in. Price: \$129. www.logitech.com

biggest disappointment

Advanced Photo System

In launching APS film in 1996, Kodak CEO George Fisher said, "In five years, you won't recognize the world of imaging." Right revolution, wrong platform: Digital cameras, not APS, led us into the 21st century.

It's not that APS is a complete bust—tiny cameras like the Canon Elph are marvels of miniaturization—but it never lived up to its considerable hype. Sure, it delivers foolproof film loading, fingerprint-free negatives and three print sizes, but these benefits are marginal. What really matters is print quality, and APS pictures range

from adequate to awful. Developers were hoping that advanced processing techniques would make up for APS's smaller 24mm film size. It didn't.

And then came digital, which now offers better quality in the same cute package. Today, there simply aren't enough advantages to APS for the format to stay afloat.—SUZANNE KANTRA KIRSCHNER



DIGITAL PIC KIOSK

Digital image processing went self-service this year, with a half-



dozen companies installing printmaking kiosks of drug stores and supermarkets. But Applied Science Fiction's stands above, making film prints as well as digital. Its Digital PIC system uses "dry" film processing—there is no water or liquid chemicals—to convert 35mm or APS film into digital pictures burned onto CDs or produced as prints. The process effectively turns any film camera into a digital. Retail photo labs could soon adopt the technology as well. www.asf.com



MINOLTA AREA-AF

Background in focus but the family blurry? A new autofocus system from Minolta makes this common mistake a thing of the past. Area-AF accesses a database of 3,000 shapes to, literally, recognize humans. If it finds one, the person is targeted as the "subject" and the camera keeps its focus on him or her—even if the person moves. Area-AF is available on the Freedom Zoom 140 (\$179) and Freedom Zoom 160 (shown, \$199). www.minolta.com

KODAK DSC PRO 14N

Built around a 13.89-megapixel CMOS sensor, Kodak's DSC Pro 14n is the world's highest-resolution digital SLR. Wide-angle shots are its specialty, thanks to one of the only true full-frame sensors around (it doesn't use a magnifier to gather light). So who needs 14 megapixels? A select few. Its two-frames-per-second burst mode certainly won't do the job at, say, a soccer game, but there's no better way to capture archival moments: portraits, weddings, landscapes. Price: \$4,995. www.kodak.com





Shell is making waves for cleaner engines.

With the cost of driving these days, don't you think it's time someone made a few waves? Well now someone has. New Shell gasoline is specially formulated to help protect your engine against the build-up of harmful carbon deposits. In fact, all three grades of new Shell gasoline exceed government standards for detergency. Because a cleaner engine equals better performance. Experience the waves of change at Shell.



GRAND AWARD WINNER FOVEON X3 SENSOR



Resolution Revolutionaries: A footnote in the papers of Dick Merrill (left) prompted Dick Lyon to create a better digital-camera image sensor. Caught here at Foveon's testing studio.



Foveon's X3 image sensor technology, which promises to spawn digital cameras that create more vivid pictures, was a colorful gem of an idea that was buried for a time among the startup's intellectual property documents and would-be patents. In the late 1990s, the company was focused on perfecting high-end digital cameras using color-separating prisms, a notion that was proving costly and a tough sell. Then chief scientist Dick Lyon spotted something in the

papers of colleague Dick Merrill—known in-house as the “mad scientist” of image sensors—that caught his eye: Silicon itself can make for a pretty good color separator.

It was known that red, green and blue light penetrate silicon to different depths. But no one had figured out how to embed photodetectors into silicon layers and turn the physics into a working blueprint—until Merrill included a two-page description of the process in a paper he wrote about another experi-

[\[CONTINUED ON PAGE 130\]](#) ►

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TestPages

edited by WILLIAM G. PHILLIPS with TREVOR THIEME

This Is Oil. Suck It Up

We train with the elite crews and high-tech gear that deal with petro-messes.

THE DESMI TERMINATOR is a big hydraulic skimmer that slurps up heavy to medium crude oil like nobody's business. The trick, though, as anyone who has skimmed fat off chicken soup knows, is to get maximum oil and a minimum amount of the stuff it's floating on. Now imagine skimming 300 gallons of fat in heavy seas: That's what it's like to run the Terminator.

Right now I'm not finding it easy: The machine bounces on the swells as I lean on the throttle—too slowly at first, but then I let 'er rip. With a throaty roar the muddy-brown slop starts to disappear into the skimmer's mouth. "Don't pump too fast or you'll empty the tank instead of the oil," warns Mike Crickard, a retired Coast Guard lieutenant commander.

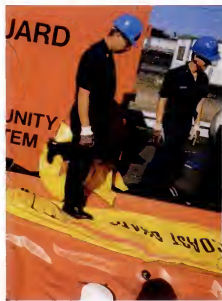
More than 14,000 oil spills are reported annually, ranging from small harbor messes to potential environmental disasters. But because federal laws prohibit open-water cleanup training with even a drop of crude, there is only one place in America to train with the real thing—the Oil and Hazardous Materials Simulated Environmental Test Tank in Leonardo, New Jersey, where today I've joined a Coast

(CONTINUED) ►



PREPARING FOR THE WORST From Ohmsett's mobile bridge, Coast Guard instructors and students contain a simulated spill with a Fast Sweep Boom.

In rough water, a 50/50 oil-water ratio gets a passing grade.



Guard oil-response training camp.

A motorized flap at one end of this 2.6-million-gallon saltwater pool generates waves as high as 3 feet, as well as harbor chop when the artificial beach is lowered. A metal bridge moves at up to 6.5 knots to mimic ocean current. An underwater propane bubbling system generates in-situ fires. Measuring almost two football fields in length, this is the largest spill response simulator in the world.

My 20 classmates are future oil-response experts, some of whom may end up in the Coast Guard National Strike Force—three elite units of men and women who are the first on the scene anywhere in the country when a tanker collides or runs aground, and are able to launch a full-blown cleanup operation in as little as an hour. Intensive weeklong courses such as this one train crews to use equipment like the “vessel of opportunity skimming system,” which can load onto any boat at least 60 feet in length. But the Jersey site, known as Ohmsett, is also the proving ground for the latest cleanup technologies, such as Corexit 9500, a liquid dispersant that breaks oil into tiny

LEARNING TO CLEAN Water jets (top left) push oil into a Fast Sweep Boom (top right) under an instructor's watchful eye; students inflate the Sea Slug (bottom right) and Lancer barge (middle), which contain retrieved oil; the writer (in the sunglasses) tries his hand at the Desmi Terminator.

droplets that biodegrade naturally in water (provided the location is at least 3 miles offshore and the depth is 30 feet or more), and the oddly named Morice, which stands for Mechanical Oil Recovery in Ice Infested Waters. Morice is a lifting grated-belt skimmer prototype that fishes oily ice out of the sea and cleans it with high-powered water jets.

I watch as students deploy an Oil Stop Fast Sweep Boom, an inflatable, urethane-coated polyurethane containment device with a net that helps trap oil in a V-shaped apex. Crickard then shows me how to inflate the Lancer barge, a 51-foot covered raft that temporarily stores up to 28,000 gallons in a bladder that extends 8 feet below the surface.

But the true test is how adeptly I operate the Terminator, which sucks up oil with an Archimedean screw. The Coast Guard doesn't have a separator—everything gets towed back to port—so recovery is all about finessing the skimmer to get maximum oil at the spill site. In still water, a 9-to-1 oil-to-water ratio is considered a good number. But when it's rough, 50/50 is a passing grade. By that standard, I do OK: 57 percent of the 28 gallons I recover is oil.—DAVID SPARROW



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King Cobra Talks Hybrids

Carroll Shelby mulls future tech and takes potshots at Detroit.

CARROLL SHELBY IS NOW 80 years old, but he's still moving fast and pulling no punches. After making his name as a racecar driver in the 1950s, Shelby developed hot rods for Ford and Chrysler and, of course, was the man behind the legendary Shelby Mustang Cobra.

We caught up to him recently to talk about the latest iteration of his Series 1 sports car, but he had other things on his mind: new technology and the future of the automotive industry. Specifically, Detroit's future, and how Shelby thinks the Big Three auto companies are screwing up. —DAN CARNEY

POPULAR SCIENCE You say that in 1982 you predicted hybrids would hit the streets in force in 2002. How did you know?

Carroll Shelby It always takes roughly 20 years for new technology to come into its own.

PS Many companies are working on hybrids, and a few, like Honda, have brought them to market. What do you think of today's hybrids, and what has Detroit's response been?

CS Detroit is trying to build hybrids with big V8s and crap that doesn't make any sense. They're sending out press releases about increasing fuel mileage from 14 to 16 mpg when they should be doing 60 to 70. They've let the Japanese beat 'em again.

PS What's the core reason for that?

CS The Japanese seem to spend a lot more on research and development for these things, and even with limited production, they're benefiting from a hell of a lot more information than Detroit. The Germans claim they're ahead as well, but I don't see it.

PS Look ahead 20 years. What automotive technology being tested now will survive and come into its own?

CS The people I trust say we'll have



"Detroit is trying to build hybrids with big V8s and crap that doesn't make any sense."

[mainstream] fuel cells in 20 years, but they'll power electric generators for our homes before we have them in vehicles. I'm 80 years old now and I probably won't see it happen.

PS Shorter-term then. How are your new cars coming along?

CS The EPA and CARB are only holding us to 95 percent of the rules they hold General Motors to, but it's still a long hard struggle with a little company. The Series 1 [which has a souped-up Oldsmobile Aurora engine] is a 3.7-second 0-to-60 car, and it handles beautifully. We are recertifying 250 of them for 2003 and 2004.

PS Your first Cobra debuted in 1962. What can we expect from the 2003 model?

CS We'll introduce the new Cobra at the North American International Auto Show in Detroit in January, although we'll have a rolling prototype at SEMA in November. It still has a Ford V8 engine, but the chassis is more advanced. The rigidity of the old one was 700 pounds [per degree] of flex. We're up to 18,000 to 20,000 pounds for the new carbon-fiber chassis, and 12,000 pounds for the Series 1's aluminum and honeycomb chassis. That extra stiffness provides better control over the suspension, and better handling.



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• games

3 for Under the Tree

Amid the deluge, three games that advance the state of digital diversions.

UNREAL TOURNAMENT 2003

(PC, \$49.99)

The Plot: Warriors face off like gladiators in a bloodthirsty future sport.

Cool Tech: Unreal

Engine, which raises the bar for sound and graphics, and a complete set of editing and development tools.

Added Realism: Karma System, featuring Ragdoll. If you like gore, know this: "When you shoot a character, the body contorts perfectly," explains lead programmer Cliff Bleszinski.

Inside Scoop: Download the demo at www.unrealtournament2003.com. The animation and environments are addictive.



ANIMAL CROSSING

(GameCube, \$49.95)

The Plot: Pokemon meets the Sims.

Cool Tech: A \$10 cable connects Game Boy Advance to GameCube, opening new worlds and downloadable activities. E-Reader (\$40) scans info on collectible cards.

The Catch: Runs on a realtime clock. Skip playing for a week and the neighborhood changes in unexpected ways.

Inside Scoop: Too mellow for me, but my 18-year-old daughter loves it.



SOCOM: U.S. NAVY SEALS

(PlayStation 2, \$59.99)

The Plot: You're an elite SEAL commander who takes on hostile forces.

Cool Tech: Headset

and voice recognition let you bark orders at A.I. teammates in single-player mode. A \$40 Network Adaptor lets you bark them online at squad mates.

Inside Scoop: Voice chat works well, but playing online leads to schoolyard-type arguing. —STEVE MORGENTHAU



NEEDLE IN A HAYSTACK
Geologists sift through tons of crushed rock for rare Yukon emeralds.

• mining

There's Green in Them Thar Hills

Our man heads north in search of Canada's newest gem.

High on Regal Ridge, deep in Canada's Yukon Territory, Bernie Gaboury examines a dull brown chunk of rock. "This is a nice sample," he says, pushing up the brim of his white hard hat. Not that I can tell: It appears no different from the thousands of rocks that have tumbled off the conveyor belt all afternoon. But when Gaboury holds it to the summer sun, several green flecks glow between cracks in the quartz crystals. These particular emeralds fluoresce in sunlight, he notes.

The Yukon has long been a source of gold and silver, but not until four years ago did anyone believe it held emeralds. That's when field geologist Bill Wengynowski discovered Canada's first, and so far only, emerald deposit. Two years ago, Gaboury and his partners at True North Gems acquired Regal Ridge and set up shop. The goal now is to determine if there are enough emeralds in the region for a commercial operation. Bulk samples collected over the summer should indicate the emerald concentration in each vein at Regal Ridge, but Gaboury will also look

farther afield. By decoding the site's geochemical signature this winter, Gaboury will obtain an essential clue for tracking down other deposits. Tough terrain and legal red tape make for slow progress, though: Another five years may pass before Yukon emeralds reach the market. —STEVE FEATHERSTONE

GLOWING GREEN A closer look at a rock from Regal Ridge reveals the telltale glimmer of emeralds.



Present Times



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waters get a needed update.

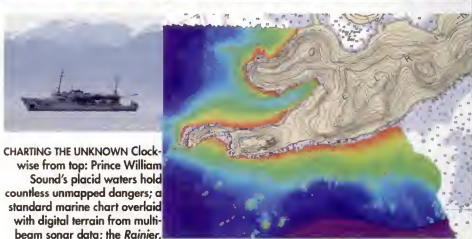
IF THIS KEEPS UP, THE DATA will be unusable," shouts Elaine Stuart as our survey launch pitches into another 8-foot swell and diesel exhaust pours into the cabin. The cox-swain, spinning the wheel from port to starboard, struggles to keep our bearing as the multibeam sonar pings the ocean floor with acoustic waves. In the end, however, his efforts pay off—we collect good data for the first high-resolution map of Prince William Sound.

The crew of the *Rainier*, the National Oceanic and Atmospheric Administration's most advanced hydrographic research vessel, is running lines off Alaska. This ship was commissioned in 1968 with the goal of charting 33,000 square nautical miles with single-beam sonar, which captures roughly 10 percent of the bottom terrain. But since upgrading to multibeam sonar four years ago, the *Rainier* now scans a full 100 percent.

When the *Rainier* is finished, mariners and scientists will have high-quality maps detailing every basin, fissure, pinnacle, hole and glacial plain on the ocean floor. And not a minute too soon: The lack of updated sea charts, coupled with sharp increases in commercial traffic and the geologically volatile nature of Alaska's coast, is a recipe for maritime disaster.

"Some soundings on the charts go back to Captain Cook," says *Rainier*'s captain, Jim Gardner. Back then sailors dropped lines with lead weights into the ocean to record depths. "Now we record objects on the seafloor as small as 30 centimeters."

Of particular interest is evidence of the 1964 Good Friday earthquake. Geologists have long suspected that uplift from the quake—which tipped the



CHARTING THE UNKNOWN Clockwise from top: Prince William Sound's placid waters hold countless unmapped dangers; a standard marine chart overlaid with digital terrain from multibeam sonar data; the *Rainier*.

Richter scale at 9.2—spawned the tsunamis that leveled coastal towns from Seward to Valdez. But the exact location and extent of the uplift has remained a mystery.

Plowing back and forth through the waves off Elrington Island, our launch's multibeam sonar paints the seafloor with a fan of acoustic waves 13 times every second, translating the time it takes for the echoes to return to the boat into depths. The coxswain, meanwhile, runs the boat in a series of parallel lines to ensure overlapping coverage, a process known as "mowing the lawn."

After 8 hours, we head back to the *Rainier*, where our data is transferred to the ship's mainframe for "cleaning." Software compensates for pitch and roll, as well as sound velocity, water density and salinity. The resulting three-dimensional bathymetric terrain model shows a color shift extending toward nearby Danger Island. It's the first direct evidence of the '64 quake in Prince William Sound.

"There's probably 30 feet of uplift along that line," exclaims Dave Sinson, the *Rainier*'s physical scientist, tracing it with his finger. "It's amazing how much of our history is underwater." —STEVE FEATHERSTONE

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2003 Snowmobiles: Hot

New technology makes this a great year for high-performance sleds.

PLUMES OF POWDER ARC behind me as I peel off the main path and thunder along a 20-mile stretch of bumped-out, mogul-strewn trail in the Payette National Forest above McCall, Idaho. I'm testing 2003 snowmobiles, and not since independent front suspension hit the scene in the early 1980s has there been such an explosion of new technology.

Three models define the revolution: Ski-Doo's \$7,049 MX-Z REV, Arctic Cat's \$7,999 F7 Firecat and Yamaha's \$8,849 RX-1. Today's ride is the Ski-Doo MX-Z REV, which introduces a riding style familiar to any off-road motorcyclist. Conventional snowmobile ergonomics place the driver aft on the seat with arms and legs extending forward. The REV shifts the rider's butt forward 12 inches and up an inch, making it easier to use your legs to soak up bumps. One flaw: By the end of the day, my knees are bruised from banging the hard plastic cowl through turns.

The next morning, I hit the trails with Arctic Cat's F7 Firecat. On hard-packed groomed trails the Firecat is spectacularly agile. Think about turning and the Firecat reacts. Squeeze the throttle and it leaps forward. Many of its components multitask, including the 13-gallon molded-plastic fuel tank, which has reservoirs for engine oil and coolant and supports the steering post. Reduced track width and a narrowed aluminum chassis help keep weight to a minimum. Its 140-hp 698cc two-stroke fuel-injected engine has twin horizontal cylinders, and its



SKI-DOO
The MX-Z REV's dirt bike ergonomics help riders soak up the bumps.

ARCTIC CAT
Conceived on the Sno-Cross circuit, the agile F7 Firecat is bred for speed.



YAMAHA
The RX-1 may be an earth-friendly four-stroke, but it'll keep up with the best two-strokes.

fuel system and exhaust are on the same side to lower the center of gravity.

Yamaha's RX-1 represents one of the first steps toward the EPA's mandate for 30 percent reduced hydrocarbon and carbon monoxide emissions by 2006. While other four-strokes compromise power for cleanliness, the RX-1's 145-hp 998cc four-cylinder, twin-cam, five-valve mill

purrs like a high-strung Superbike. With good reason—this is a winterized version of the engine that powers Yamaha's mighty R-1 motorcycle. The RX-1 requires electric starting, which adds the weight of a battery and starter motor, but the engine is silky smooth and smoke-free even on cold starts. At 550 pounds, it's no lightweight, but it'll rocket across a frozen lake at triple-digit speeds. Good, clean fun. —CHARLES RUEDDEMANN

WINTERTIME TECH FOR BACKCOUNTRY FUN

Ski-Doo Auto-Air Rear Suspension
A hydraulic shock absorber settles when parked, then uses energy from bumps to pump itself to ride height.

Arctic Cat Remote Starting
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Polaris Series 4 RMK
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Polaris Pistons with Grafal
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Whoever said getting there was half the fun was only half right.



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• books OPAQUE [1 2 3 4 5] ENLIGHTENING

Entangled in Weirdness

A clear look at a mighty wacky reality.

a MIR ACZEL WRITES BOOKS that explain the virtually unexplainable to people who have virtually no chance of understanding it: hard work, but he does it well. In *Entanglement*, Aczel tells the story of one of the most bizarre and counter-intuitive phenomena in the strange world of quantum mechanics.

Many readers will know that particles at the subatomic level are subject to their own set of rules, one rule being that uncertainty (about, say, momentum and position) is built into the system. A photon, for example, will exhibit both particle and wave characteristics and do odd things like pass through two holes at once and then interfere with itself.

Entanglement is the special relationship between two particles such that when something happens to particle A, particle B is instantaneously affected no matter how far away it is from particle A. Entanglement was first proposed mathematically by quantum theorists who, in the 1920s and '30s, had no way of testing it. The concept seemed to violate relativity itself, which holds that nothing travels faster than the speed of light; what "signal" could particle A send to particle B to effect the instantaneous change? Einstein, the father of relativity theory and a key figure in the development of quantum theory, rejected what he called "spooky action at a distance." Yet lab experiments in the '70s confirmed it: instantaneous changes in two particles in conditions where no "signal" could pass.

This is a good book. Aczel repeats the basics, and anchors the story in the lives and adventures of physicists. It is not a beautiful book, though—somewhat clunky, too episodic, lacking in a grand overview. The nonscientist emerges uncertain of his own understanding—but still enriched for being entangled in a great mystery.—SCOTT MOWBRAY

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EDITED BY BOB SILLERY
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Why can you sometimes see the moon during the daytime?

Barry Dewitt

Toronto, Ontario, Canada

The moon appears in the daytime sky in all of its phases, though it's sometimes difficult to pick out. The best time to spot the moon in the daytime, says astronomer John Mosley of the Griffith



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Observatory, is about two days after the arrival of the full moon—a viewing opportunity that will continue for about a week: “That’s when the moon is big and bright and in the opposite part of the sky from the sun, so that the brightness of the sun does not overwhelm it.”

As the phase of the new moon approaches, the moon is in the same direction as the sun in the sky and becomes hard to detect. The crescent moon is also very difficult to spot.

The best viewing time for the just-past-full moon, says Mosley, “is in the darkest part of the sky, toward the southwest, shortly after sunrise.”

My mom’s soy milk has isoflavones in it. The carton says they contribute health benefits, but it doesn’t say what they actually do. Is this a marketing scam?

James Weber
Reading, Pa.

You are right to question the claims on the carton. From miracle weight loss treatments to vitamins, minerals and exercise equipment, consumers spend billions of dollars each year on health products—many of which are unproven and don’t live up to their hype.

But in this case, you can rest assured that no marketing team is pulling a fast one. Soy milk and other soy products do indeed contain isoflavones, and most health experts agree that these

phytochemicals—that is, compounds found only in plants—are beneficial.

Soy is well known for reducing heart disease risk, lowering cholesterol, warding off breast cancer and easing postmenopausal symptoms in women. Many scientists think that isoflavones are the components of soy responsible for producing these health benefits. Also called phytoestrogens, isoflavones are thought to look and act like the female sex hormone estrogen. In the case of breast cancer, isoflavones may mimic estrogen and compete with the hormone

for binding sites on breast cancer cells that depend on estrogen for tumor growth. Similarly, isoflavones may fill in for the estrogen that is reduced when women reach menopause, thereby easing the hot flashes, mood swings and water retention associated with fluctuating estrogen levels. Exactly how isoflavones work to reduce heart disease risk and lower cholesterol is less clear, though it is probably hormone-related.

[CONTINUED ON PAGE 126] ▶

WORD WATCH

Impress your friends with science jargon!

IN SILICO: Why say that you are using a computer to perform a test? It’s more hip to say that you are running the test *in silica*. This word is a variation on two terms that came into existence in the 19th century. *In vivo*, or “in that which is alive,” means that you are experimenting on a living organism. *In vitro*, or “in glass,” means that your research is being performed in a test tube or culture dish. Now we have “in silican,” or on a computer. So, for example, students who are too squeamish to dissect a frog, or oppose the practice for ethical reasons, can perform the procedure *in silica*. World Wide Words (www.quinlan.com/words), which studies this sort of thing, speculates that the construction must have originally been “a computer scientist’s joke.” But now there is even a magazine called *In Silica Biology: An International Journal on Computational Molecular Biology*.

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JUST THE FACTS

Diabetes

Diabetes develops when the body fails to produce or properly use insulin, a hormone that ensures cells get the glucose they need for energy. Without insulin, glucose accumulates in the blood, damaging eyes, kidneys, blood vessels and nerves.

About 17 million people in the United States (6.2 percent of the population) have diabetes; 5.9 million of these don't know it. Projections indicate that the number of Americans with diagnosed diabetes will reach 29 million by 2050. Experts see a correlation between these numbers and factors like rising levels of obesity, poor diet and an aging population.

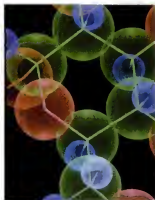
In Type 1 (juvenile) diabetes, the immune system destroys pancreatic cells that produce insulin. Type 1 usually occurs in children and young adults.

A majority of diabetics—90 to 95 percent—have Type 2, in which the body doesn't make enough insulin or use it properly. Type 2 most often occurs after age 45. It can sometimes be controlled with diet and exercise. Oral medications or insulin injections may be necessary.

Among U.S. adults ages 40 to 74, at least 16 million (15.6 percent of the population) have pre-diabetes, a condition defined by blood glucose levels that are higher than normal, but not high enough for a diagnosis of diabetes. The Diabetes Prevention Program, a study by the National Institutes of Health, shows that diet and exercise can play a positive role in warding off the onset of Type 2 diabetes.

With no known cure, diabetes is the sixth-leading cause of death in the United States.

University of Miami and Pfizer researchers are testing an insulin inhaler for Type 1 diabetics—one of many at-



Part of a molecule of insulin, which regulates blood sugar.

tempts to find a replacement for needle pricks. But inhalation is much less efficient than injection for delivering insulin to the bloodstream, so diabetes experts doubt it will ever fully replace injection.

Hoping to produce better oral drugs for Type 2 patients, Swedish researchers are experimenting with drugs that inhibit DPP IV, an enzyme that breaks down hormones which help control blood glucose.

Children whose diet lacks vitamin D, an immune system suppressant, could be more likely to develop Type 1 diabetes, say Finnish researchers.

Scientists at Howard Hughes Medical Institute have found that nestin-positive islet derived progenitor cells, a type of stem cell, can be transformed into the fully functioning insulin-producing cells missing in Type 1 patients.

The TheraSense FreeStyle Tracker Diabetes Management System is a first-of-its-kind glucose monitor that is integrated into a PDA. The device tests glucose levels and connects to any Handspring Visor to provide a readout on the PDA screen and enable patients to track results.

ISense Corp. is developing a wireless, minimally invasive under-the-skin microsensor to monitor glucose levels and transmit information to a receiver, and from there to the patient's doctor.

—COMPILED BY JENNY EVERETT

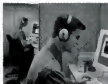
And when you're not listening to music, you can use it to quietly enjoy a little peace. Clearly, the Bose QuietComfort headset is no ordinary headset. It's no exaggeration to say it's one of those things you have to experience to believe.

Whole Earth describes this headset as "perfectly wonderful," especially when you "need to listen anywhere there are a lot of background distractions." That's because the QuietComfort headset actively monitors and counteracts unwanted noise and reduces it before it reaches your ears. It recognizes what you're about to hear and compares it with what you want to hear — music, or silence itself. Patented Bose technology then counteracts the noise and delivers the sound you want. *Upscale* magazine calls this headset "revolutionary." Respected columnist Rich Warren hails it as his "product of the year." *Stereo Review's Sound & Vision* reports that it "can be a terrific antidote for delayed flights, engine noise, crackly airline headphones, and all the other nuisances passengers encounter."

Enjoy your music with Bose sound quality. The QuietComfort headset arrives ready to use with your portable CD/DVD/MP3 player, home stereo, laptop or office computer and in-flight entertainment systems. As *Men's Journal* reports, it "puts the wearer in a zone of blessed quiet, then fills the ears with rich stereo sound." The *Boston Globe* calls the audio quality "superb." Travel expert Rudy Maxa finds it "stunning." Just what you expect from the most respected name in sound.



So comfortable, you may forget you're wearing it. With a weight of only 5.4 ounces, the QuietComfort headset nestles lightly around your ears. Audio critic Mark Fleischmann calls it "the most comfortable full-sized pair of headphones I've ever used," with the "softest earpads I've encountered in 30 years of wearing headphones."



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DOI: 10.1002/ajim.20255 **Abstract:** *Background:* The purpose of this study was to determine the prevalence of musculoskeletal disorders (MSDs) among U.S. commercial truck drivers. *Methods:* Data were obtained from the 2002 National Longitudinal Study of the U.S. Adult Population, a nationally representative survey of the U.S. adult population. The survey included questions on the prevalence of MSDs among truck drivers. *Results:* The prevalence of MSDs among truck drivers was 15.5%. The most common MSDs were back pain (10.5%), neck pain (8.5%), and shoulder pain (7.5%). The prevalence of MSDs was higher among truck drivers who were older, had a higher level of education, and who had a longer duration of truck driving. *Conclusions:* The prevalence of MSDs among truck drivers is high, and it is important to develop interventions to reduce the risk of MSDs among this population. *Keywords:* musculoskeletal disorders, truck drivers, prevalence, risk factors.

FYI

Soy's clean bill of health has been challenged by research that suggests soy might actually increase breast cancer risk in postmenopausal women. However, experts say the most recent evidence still supports the notion that soy decreases breast cancer risk.

Women seem to reap many of the benefits from soy, but research focusing on benefits for men may soon get more attention. Promising studies are building the case that soy may reduce prostate cancer risk. Also being investigated is how soy may influence osteoporosis, cognitive function and kidney function.

Scientists suspect that in addition to isoflavones, there may be other health-promoting substances in soy, including the soy protein itself and other non-isoflavone components. Soy has high-quality protein, which

makes it a desirable substitute for meats, and soy that has been processed with calcium can be a good substitute for dairy products.

Therefore eating whole soy foods—soymilk, tofu, textured soy protein, tempeh and miso—is likely a better bet than popping isoflavone pills in supplement form. For maximum health benefits that balance the possible risks, experts recommend consuming soy foods in amounts that provide 10 grams of soy protein per day, or the amount in about 1 cup of soymilk.

Is the International Space Station visible to the naked eye in the night skies?

Jason McMurry
Idaho Falls, Idaho

Like many other satellites, the International Space Station is occasionally bright enough in the night sky to be seen by the naked eye. It is in one of the lowest orbits possible, about 242 miles overhead. The ideal viewing time is immediately before dawn or after sunset, when the observer is in



Sunlight glinting off the International Space Station's solar wings helps make it visible.

the dark and the ISS is in sunlight. Circling the globe in slightly different orbits 15 times a day, the ISS passes over most of the Earth in a 24-hour period. A number of Web sites will tell you when the ISS will pass over your location—www.heavens-above.com is one. (This site has more than 2 million cities and towns in its database.) Traveling at about 4.8 miles per second, the station is not likely to be over your home for more than about 10 minutes. ■

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15th ANNUAL BEST OF WHAT'S NEW

AUTO TECH (FROM PAGE 64)

since changed a bit, though it still emphasizes separate manufacture and sale of bodies for the skateboard.

Electrical drive-by-wire links replace mechanical and hydraulic ones, meaning that even the controls could be moved to different positions. Seats and features could be added or removed to create a rolling office one week, a two-person sleeping vehicle the next.

In September, GM took its first stab at demonstrating the kind of body that would capitalize on Autonomy's versatility. The company produced a driveable prototype called Hy-wire, a sedan in which the windshield extends to the driver's feet. With key fuel-storage and electric-motor technology yet to be developed, the Hy-wire's skateboard is not yet as compact as the Autonomy vision calls for, but GM is thinking long-term. "Autonomy is our vision of the future, let's say about 2020," says Borroni-Bird.—TED WEST

AVIATION & SPACE (FROM PAGE 72)

the Williams EJ-22 engine, developed by the pioneering Sam Williams, whose early powerplants helped make cruise missiles feasible and launched the first generation of light business jets. The EJ-22 weighs just 85 pounds, yet, thanks to its well-tuned fan aerodynamics, produces 770 pounds of thrust, giving it the highest thrust-to-weight ratio of any commercial turbofan ever made. The six-stage compressor is machined from a single piece of metal, and the engine control system is built into the Eclipse's avionics—both advances that help to keep costs low. Eclipse partially funded the engine's development and has exclusive rights to it for five years.

As NASA and others envision an air taxi system of small-airport jet service for businesses and point-to-point travelers, Eclipse appears well timed. There are hurdles, of course: The plane needs FAA certification (targeted for December 2003) and enough customers to float Raburn's business. But at \$850,000, less than a quarter the cost of a basic Lear or Cessna, Eclipse has a shot. "This flight validates everything we've been saying," Raburn said after the Eclipse's maiden voyage. "There is a better way to produce aircraft."—ERIC ADAMS

MEDICAL TECH (FROM PAGE 76)

destroyed the pig organs within a day. It turned out the animals' disease-fighting antibodies recognized as alien a sugar called alpha-1,3-galactose on the surface of pig cells. People possess the same antibodies and so would reject pig organs just as quickly.

Julia Greenstein, CEO and president of Immerge, a joint venture between BioTransplant Inc. and Novartis Pharma AG that's partnered with the Missouri scientists, and Immerge's director of animal genetic engineering, Robert Hawley, decided to create a pig whose DNA was missing a gene called GGTA1, which is responsible for attaching the critical sugar to pig cells. In March 2001, the team achieved proof of concept: They produced a pig with an extra gene, one from a jellyfish that causes fluorescence (the pig's nose was a vivid yellow). Next, the scientists created the world's first so-called knockout pigs, each missing one copy of the GGTA1 gene. Because pigs, like humans, have two copies of the gene, the researchers will have to get rid of both to evade the antibodies. Assuming animal-rights objections don't slow them down, human trials could begin within three years. "When I look through the microscope at an early pig embryo, I used to see pork chops," Prather says. "But I'm starting to see organs that can be used for humans."—DAN FERBER

COMPUTERS (FROM PAGE 80)

slide the core into a shell with a touch-sensitive LCD display and appropriate controls and voila. If you need a laptop, the same core slips into a shell with a keyboard, screen and speakers. The core module possesses the processing power and all your stored data, applications and settings. "What we really wanted to be able to do was separate the computer from how you interact with it," Ocheltree says.

IBM has licensed the MetaPad design to Antelope Technologies, which has renamed it the Mobile Computing Core (MCC). In addition to the core (\$2,600), Antelope is offering a desktop cradle (\$495), a handheld unit (\$1,400), a laptop module (about \$1,600), a wearable cradle (\$600) and head-mounted display (\$2,000). In the near future, the company plans to unveil mini-tablet and mega-tablet devices.—STEVE MORGENSTERN



Is it possible for a single stem cell
to divide an entire nation?

Join the conversation.

RECREATION (FROM PAGE 84)

too heavy). The only way Pope could think of—make the top and bottom separately, then connect them with a seam along the edges—would compromise durability and could cause leaks. "In the back of my mind I thought there must be a better way," he recalls. In 1997, he found it: internal pressure bagging, a technique

in which carbon fiber is placed into a mold and heated while pressure from a balloon holds it against the sides.

Pope decided to use this process to make a board in two halves, each hollow, then join them with his patented Bisect Joint technology. The only seams are on the bulkheads, where they are safe from major impacts. All this tech comes at a price: The Stealth, due out this month, will cost \$1,795, about \$1,000 more than an ordinary longboard. —MARK ANDERS

HOME TECH (FROM PAGE 88)

cookies: all good. Even finicky angel food cake was appropriately light and fluffy. The team told me they'd specified how much the cake's cell structure should expand; all I know is I ate the whole piece. The oven will be available in the spring for about \$2,500. —CHARLES WARDELL

GENERAL TECH (FROM PAGE 94)

How does it work? The piezoelectric transducer emits sound at frequencies above the human ear's 20,000-cycle threshold. Unlike low-frequency waves, the high-frequency signals don't spread out as they travel through air. Yet they do interact with the air to induce a related set of ultrasonic waves. These waves combine with the original waves, interfering to create an audible signal, focused into a beam.

The applications are numerous, if not apparent: Thousands of soda machines in Tokyo will soon bombard passersby with the enticing sound of a Coke being poured, and several U.S. supermarkets will promote products to shoppers as they walk down corresponding aisles. Eventually HyperSonic Sound might enable a nightclub to play disco on one side of the dance floor and salsa on the other. Ambulances equipped with hyper-sonic sirens could clear the streets without waking the neighbors. Norris' company, American Technology, sells the devices for \$600. —DAVID SPARROW

PHOTOGRAPHY (FROM PAGE 100)

ment. "I thought to myself, 'You can do this,'" recalls Lyon.

Conventional sensor technologies use a single layer of photodetectors; every third pixel senses either red, green or blue. The camera then fills the spaces between those pixels using educated mathematical guesswork known as interpolation. Foveon's X3, by contrast, employs three layers of detectors to capture each color at each pixel, making interpolation unnecessary. The result: more accurate color and finer detail. POPULAR SCIENCE compared the \$1,800 Sigma SD9 (the 3.5-megapixel SLR that debuts the Foveon) to the 6-megapixel Canon D60 (\$2,699) and the Nikon D100 (\$2,500). The Sigma won on sharpness and held its own in other categories. —CHRIS O'MALLEY

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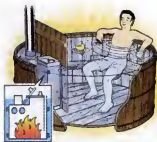

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- PUBLICATION TITLE: Poplar Science
- PUBLICATION NO.: 577-250
- FILING DATE: September 25, 2002
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- FULL NAMES AND COMPLETE MAILING ADDRESS OF PUBLISHER, EDITOR AND MANAGING EDITOR: Publisher, Denise Anderson, Time 4 Media, Inc., 2 Park Avenue, New York, New York 10016; Editor: Scott McElroy, Time 4 Media, Inc., 2 Park Avenue, New York, New York 10016; Managing Editor: William G. Phillips, Time 4 Media, Inc., 2 Park Avenue, New York, New York 10016
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14. ISSUE DATE FOR CIRCULATION DATA BELOW: September 2002

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a. Total No. Copies (Net Press Run)	1,726,626	1,684,593
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1. Paid (Requested Outside-County Mail Subscriptions Stated on Form 3541, (Include Advertiser's proof & exchange copies)	1,361,608	1,327,711
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Traveling to Floyd Bennett Field in New York City, we observed air squadrons drilling in intricate maneuvers. Among the benefits of close-formation flying: protection, saturation bombing and the ability to bring concentrated gunfire on attacking planes. Five planes might form a V, for example, with a sixth plane flying sheltered within it. The BT-9s depicted here were used extensively for training.

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